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EGGS

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THE PRODUCTION, IDENTIFICATION AND RETENTION OF QUALITY IN EGGS

DOMINION DEPARTMENT OF AGRICULTURE

OTTAWA CANADA

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DOMINION OF CANADA, DEPARTMENT OF AGRICULTURE

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THE PRODUCTION, IDENTIFICATION AND RETENTION OF QUALITY IN EGGS

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FOREWORD

THE bulletin "Production, Identification and Retention of Quality in Eggs", was first published by the Ontario Department of Agriculture under the authorship of Professor Earle S. Snyder, of the Poultry Department, Ontario Agricultural College. The material, including photographs, was originally assembled for lecture purposes in the poultry courses offered at the Ontario Agricultural College. It proved so popular in this form, and in the form of illustrated lectures for public meetings, that it was decided by the Provincial Department to incorporate it in bulletin form. At the time of its publication arrangements were made for the publication of a special extra edition to be printed on requisition from the Dominion Department of Agriculture and made available for distribution throughout Canada.

That edition has now been exhausted and with the consent of the Ontario Department of Agriculture, permission has been given to print the bulletin as a Dominion publication with a foreword giving due credit to the Provincial Department and the author, Professor Earle S. Snyder.

This bulletin fills a long-felt need. It is really the first time in Canada that much of the information available on egg quality has been given in a co-ordinated way and the ready response with which the bulletin has been received is proof of its appreciation by the general public.

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INTRODUCTION

Eggs have long held an important place in the human diet. They were easy to prepare for food and people liked them; thus a more or less satisfactory market was always available. Competition among foods was also relatively mild and thus the availability of eggs, price and their attractiveness of appearance were the main factors influencing their use.

Recent nutritional investigations have, however, changed all this. The housewife has become food conscious. Foods are now carefully evaluated before purchase; their vitamin and mineral content studied. The quality of protein, amount and digestibility of the fat and the ease and economy of preparation are matters of great importance. Flavours are delicately tested and even fitness in the meal's colour scheme is a matter of moment. Result—a keen competition in the use of foods, dependent on their nutritional and other values. In this competition eggs are not exempt.

Science has, however, assigned eggs a leading role nutritionally, and the importance attached to their use in the diets of both the Armed Forces and civilians during the war has confirmed that role. Nutritionists advise an egg a day or 30 dozen per year per capita for optimum nutrition. Canadian consumption is good and is increasing, having risen 3.5 dozen per capita between 1939 and 1943. At 23.69 dozen in 1943 there is, however, still considerable room for improvement. The possibilities for future increase are a matter of conjecture.

Canada is fortunate in its possession of a highly developed poultry industry. Being largely an agricultural country, there is usually an abundance of coarse grains and their by-products and also green feeds. In normal times there is also an abundance of animal by-products. This makes the feeding of balanced rations easily possible. Advanced, widely applied breeding policies, aided by a well-organized and responsible hatchery industry, make superior laying stock readily available, and such stock is largely used. Uniform grading regulations with provision for producer grading, the application of which regulations is facilitated through an extensive system of registered egg grading stations, make it possible to satisfactorily meet the demands and needs of the consumer.

Due to the tremendous and urgent demand during the war for eggs for Britain, for the Armed Forces and increased home use, Canadian farmers and poultrymen have greatly increased their flocks to meet this need. The following table indicates the extent of this expansion.

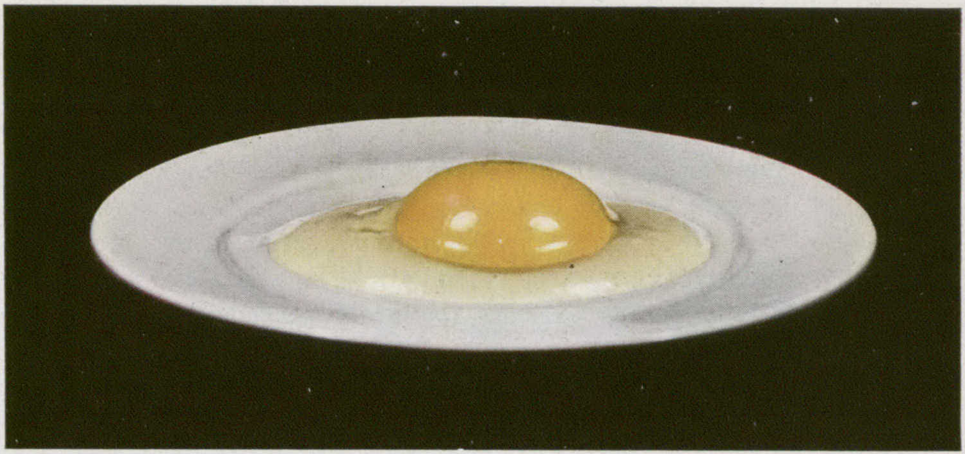


FIG. 1. Few foods are more appetizing than an A grade egg with its attractive yolk colour, high percentage of thick white and mild, delicate flavour.

TABLE I.—RECEIPTS OF EGGS FOR BRITAIN INSPECTED BY SPECIAL PRODUCTS BOARD

1939	34,394 cases of 30 dozen each
1940	355,910 cases of 30 dozen each
1941	519,357 cases of 30 dozen each
1942	1,251,198 cases of 30 dozen each
1943	1,121,427 cases of 30 dozen each
1944	2,664,325 cases of 30 dozen each
1945	2,998,170 cases of 30 dozen each

According to the Quarterly Bulletin of Agricultural Statistics, the poultry situation in Canada as to production and domestic consumption of both eggs and poultry is as follows:

TABLE 2

Year	**No. of Hens**	**Total Production**	**Production per Bird**	**Price per Doz.**	**Consumption per capita Eggs (doz.)**	**Poultry (lb.)**
1939....	24,024,000	221,737,000	111	18.5	20.10	19.49
1940....	26,420,000	235,322,000	111	19.5	20.20	20.50
1941....	25,874,000	244,157,000	113	21.4	20.35	19.53
1942....	29,236,000	280,253,000	115	29.0	22.05	23.52
1943....	32,725,000	315,027,000	116	31.9	23.69	22.72
1944....	37,245,000	360,948,000	116	29.4	24.40	26.32
1945....	37,929,000	373,925,000	118	32.0	23.37	26.62
Increase %	63.3	59.2	6.3	72.9	16.2	36.6
in units	13,905,000	152,215,000	7 eggs	13.5	3.27 dozen	7.13 pounds

Several conditions seem apparent. Producers and consumers alike need to know all available information concerning eggs. They should realize their high nutritional value and the factors influencing such values. They should also understand all factors and conditions in the production and marketing of eggs which influence quality in any way. Such knowledge should aid consumers in making maximum use of the product. It should also aid producers to so intelligently produce a maximum quality product as to enable them to successfully meet competition, whether nutritional or economic and to maintain and develop a stable remunerative poultry industry in Canada. The material in this bulletin is offered as an aid to this end.

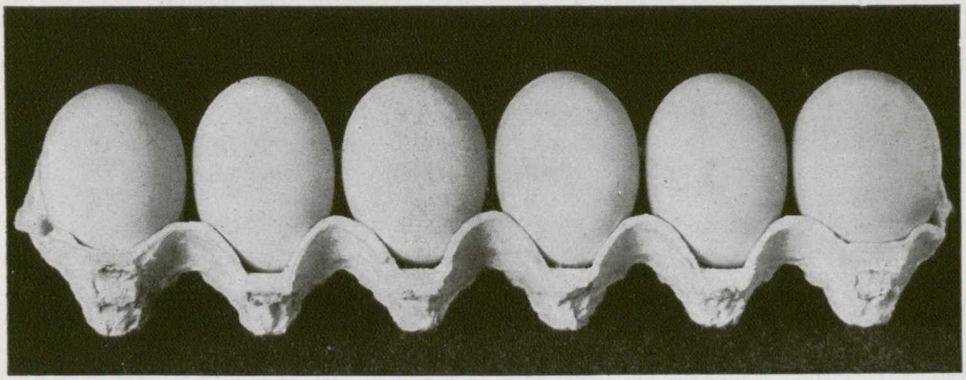


FIG. 2. Clean eggs, sound in shell and uniform in size and colour, arouse interest and encourage consumption.

WHAT IS AN EGG ?

The egg is an amazing phenomenon; it is also one of nature's outstanding foods and is the sole source of the nutrients needed to develop a healthy, lusty chick and to completely nourish that same chick for the first several days of its active life. This means that within its shell is contained all the food ingredients, perfectly balanced, for the developing chick. It also means that this same egg, when consumed by man, may, in his diet, be a very important source of balanced food of the highest quality.

When to its high nutritional value is added an attractive and appetizing appearance, great versatility of use in cookery practice and a high degree of digestibility, then one has a food of merit. To cap the climax, this food is usually practically sterile when laid, and is surrounded by a shell for protection and ease in handling.

THE FOOD VALUE OF EGGS

The importance of eggs as a food is based on several factors:

(1) **Eggs are a Protective Food**—Eggs, milk, fruits, vegetables and some red and glandular meats are classed by nutritionists as "protective foods." Why? Because:

They are rich in well-balanced proteins.
They are rich in vitamins.
They are an important source of essential minerals.

Protective foods are so called because of their ability to balance diets commonly over-rich in starches, sugars and fats and too frequently lacking in balanced proteins, minerals and vitamins.

Well controlled animal experiments have demonstrated that the liberal use of protective foods will:[1]

(a) Give better support for the mother and a better start in life for the young.
(b) Speed up maturity and produce better development.
(c) Produce a high level of adult vigour.
(d) Extend the average useful span of life.

Protective foods are a vital factor in the rearing of Canadians with strong healthy bodies and alert minds, therefore their extensive use in the Canadian diet is amply justified. Eggs are one of the protective foods.

(2) **Eggs are Rich in High Quality Proteins**—Egg protein is unique in that it is rich in all of the ten amino acids considered indispensable for growth, tissue repair and other body functions. Because of this it is called a balanced protein. This also makes it valuable for balancing deficiencies in proteins which lack essential amino acids. In this respect it is similar to the protein of milk. Egg protein is usually easily and almost completely utilized. Because of the destruction of a certain protein (avidin) which in the uncooked state makes biotin (a necessary vitamin) unavailable, cooked egg white is somewhat more digestible than when used raw. It may, however, be materially lowered in digestibility if overcooked, in which case it becomes hard and rubbery. Egg yolk protein is little injured, if at all, by cooking.

(3) **Eggs are Rich in Easily Digested Fat**—This fat is colloidally dispersed or is in what might be called an emulsified form which renders it readily digestible not only by adults but even by children as young as three months of age. This is true of few other fats. Egg fat is rich in phosphorus and in essential fatty acids. It is also the carrier of many of the vitamins present in the egg.

(4) **Eggs are an Excellent Source of Vitamins**—This is particularly true of vitamins A, D and riboflavin. One group of investigators has stated that "no other animal tissue approaches the egg yolk as a source of vitamin A except liver, which is generally more than twice as rich, weight for weight, as egg yolk."[1] As a natural source of vitamin D, egg yolk is second only to fish liver oils. It is also a good source of riboflavin (vitamin G) which is the only vitamin found in appreciable amount in egg white. Egg yolk is also a useful source of thiamin (B_1), niacin, pantothenic acid and vitamin E and a fair source of certain essential fat acids, vitamin H (or biotin), vitamin D, choline and probably vitamin B_6 and other vitamins or vitamin-like compounds. In fact eggs contain most of the known vitamins with the notable exception of vitamin C.[2]

It is important to bear in mind that the amounts of the various vitamins contained in eggs may vary considerably, dependent on the vitamin content of the feed fed to the laying stock.

(5) **Eggs are Important Sources of Minerals**—The iron content of the eggs is relatively high in comparison with other foods and is in a readily available form. Most of the iron is stored in the yolk. Eggs are also a source of calcium and are rich in phosphorus. Copper, iodine, and a number of other minerals are also present in useful amounts. The feeding of cod liver oil has been shown to increase the iron and copper content of eggs as well as that of vitamin D[3] and there is also evidence that breeding is a factor in the iron content of individual bird's eggs.

(6) **Eggs are Palatable and Useful in Special Diets**—Most people like eggs in some form or other, especially if attractive in appearance and mild in flavour. As already stated elsewhere, eggs are highly digestible, especially when not over-cooked. Physicians frequently prescribe eggs in the diets of invalids and in the treatment of a number of ailments. Eggs are excellent in the diet of the pregnant mother and growing child.

(7) **Eggs are Almost Indispensable in Cookery Practice**—Eggs are adaptable in cookery. Served either alone or combined with other foods,

which they often serve to enrich, they are palatable and attractive. They have a leavening effect in making cakes and omelettes; they prevent the clustering of ice crystals and so their use results in smooth textured ice cream. Their emulsifying properties are important in mayonnaise dressing; they also serve to thicken custards, gravies and sauces. They serve as a binding agent in meat loaves and adhere crumbs to chops and fish in breading. Sliced, diced or minced they serve as a decorative agent and when added to coffee they serve to clarify. It is for these reasons that they are considered so necessary in cookery practice.

TABLE 3 — WHAT EGGS CONTRIBUTE TO OUR DAILY FOOD REQUIREMENTS*

Food Nutrients	One Egg Contains	% of Daily Requirement for Average Adult One Egg Supplies
Protein	6.7 grams	10%
Calories	70.0	2- 3%
Calcium	0.03 grams	4%
Phosphorus	0.11 grams	9%
Iron	1.55 mg	13%
Vitamin A	200- 800 I.U	4-16%
Thiamin (B_1)	60- 120 mcg	3- 6%
Vitamin D	10- 50 I.U	3-12%
Riboflavin	100- 500 mcg	3- 7%
Niacin	760 mcg	3- 4%
Pantothenic Acid	600-1200 mcg	6-12%

* R. V. Boucher, Pennsylvania State College.

Thus a single egg supplies from 3 to 16 per cent of the daily requirement of all except one of the nine essential nutrients that are most likely to be deficient in the average human diet. The missing nutrient, vitamin C, is found plentifully in most vegetables and fruits.

It is for these and other well authenticated reasons that in Canada's Official Food Rules in the Canadian Nutritional Program, eggs are listed along with milk, fruits, vegetables, cereals and bread, meat and fish as "health protective foods." Adequate consumption of these is urged and the daily requirement of each for good nutrition is stated. The recommendation for eggs is "at least 3 or 4 weekly" with the added injunction for all of the above to "be sure to eat them every day in at least these amounts and more if one can." This program was prepared by the Nutrition Services of the Department of National Health and Welfare and approved by the Canadian Council of Nutrition. On the advice of Dr. Frederick F. Tisdall and his associates in charge of the R.C.A.F. nutritional program, 6 to 12 eggs per week per man are regularly included in the rations while in training. Somewhat similar allowances are included in the Army and Navy rations.

The following statement by Harry W. Titus, Senior Biological Chemist of the U.S. Department of Agriculture will serve well to summarize the food value of eggs.[2]

"Eggs are an important protective food. They are a fair to good source of most of the known vitamins and vitamin-like factors; they contain a good assortment of the mineral elements; they are a rich source of protein of high biological value and their fat is of unusual nutritive value.

"The nutritive value of an egg is independent of the colour of its shell. Eggs have a high coefficient of digestibility and a fairly high satiety value."

Certain properties make them of value in upbuilding diets. "Among these are their low content of sugar, the high biological value of their protein, their negligible content of purines, the availability of their iron for the formation of hemoglobin, and their high digestibility and utilization, which cause eggs to be classed among the low residue foods."

WAYS IN WHICH EGGS MAY BE MERCHANDISED

Eggs are most commonly merchandised in any of several forms:

(1) **In the Shell**—The original and most common. In this form they are readily handled and attractive in appearance. The shell affords considerable protection from outside contaminating contacts and serves as a useful individual package until the contents are consumed. It also facilitates handling in quantity in cartons and crates and is an aid in storage. All commercial grading is done while eggs are in this form.

(2) **Broken Out and Frozen**—Frozen egg meats, as whole eggs or with the yolks and whites separated, are extensively used; particularly in the baking, ice cream, candy and mayonnaise dressing trades. Stored in special containers such egg material keeps for a year or more with a minimum loss of food value and great saving of storage space. This broken out egg material is known in the trade as egg melange.

(3) **Dried or Powdered**—The practice of drying eggs has been greatly perfected during the war and is extensively used by Canada as well as the United States and several other countries. Dried eggs have been of inestimable value to the people of Britain and the Allied Armies. They are also a boon to the people of the liberated countries of Europe. Quality eggs, correct temperatures, and extreme sanitation are essentials in the preparation of a first-grade egg powder. Such an egg powder has fine flavour, a low bacterial count, high solubility, and a very low moisture content. By packing it in vapour-proof containers this quality can be retained more or less indefinitely. Preparation under proper facilities and according to up-to-date practice results in minimum loss of food value, and separate drying of whole egg meats, whites and yolks makes possible many uses.

The addition of water or milk enables the preparation of scrambled eggs, omelette, custards and numerous other dishes. The powder is also extensively used in the prepared flour, baking, ice cream, candy and other industries.

QUALITY DEFINED

Not all eggs are of the best quality, not even when freshly laid. Many factors influence quality; some prior to laying and others in the interval between production and consumption.

What is Egg Quality?—It may be defined as those conditions in an egg which:

(a) Make the egg most attractive in appearance to the consumer, both in the shell and broken out, and both raw and cooked.

(b) Render the egg of the highest nutritional value.

(c) Give the consumer maximum satisfaction and in consequence of the foregoing, bring the greatest return to the producer.

Commercially a good egg is one, preferably infertile, that has a clean, sound shell, attractive broken out appearance, and a fine, mild flavour. For maximum nutritional value, however, the eggs must be from hens in the best condition and fed on a ration rich in minerals, vitamins and high quality proteins, such as found in a hatching ration. This may, however, be uneconomical unless a special price can be procured for eggs produced from this more expensive ration.

The following tables illustrate two examples of the effect on the vitamin content of eggs brought about by additions of such vitamins to the ration.

TABLE 4—THE EFFECT OF DIET ON THE VITAMIN D CONTENT OF EGG YOLK†

	International Units (I.U.) per average egg yolk
Basal	10.26
Basal + 2% Cod Liver Oil	81.0
Basal + 2% 5X (fortified) Cod Liver Oil	153.9

†Branion, Tisdall and Drake

Eggs with as much as 48,600 I.U. of vitamin D were produced when 2% of a very concentrated form of vitamin D carrier was fed. This is, however, uneconomical.

TABLE 5—THE EFFECT OF DIET ON THE VITAMIN A CONTENT OF EGG YOLK

Diet	**Eggs Laid in 100 Days**	**No. of Eggs Analysed**	**Vitamin A Per Gram Yolk In Micrograms**	**Vitamin A Per Yolk**	**Range**
Basal	44	8	6.6	112	(89-133)
Basal + .25% C.L. Oil	58	8	7.1	124	(89-200)
Basal + .50% C.L. Oil	76	8	7.8	146	(105-195)
Basal + 1.00% C.L. Oil	74	8	8.5	155	(106-214)
Basal + 2.00% C.L. Oil	74	8	9.2	170	(136-235)

University of Wisconsin 1939

Infertile Eggs—Infertile eggs produced from good diets have equal nutritional value and in addition will keep better under adverse conditions of temperature than will fertile eggs.

HOW CAN EGG QUALITY BE RECOGNIZED?

(a) The egg may be candled. This is the commercial method and a good one, though not perfect. The type of "candle" used, as well as the eye-sight, alertness, experience, and judgment of the operator are all important factors in efficient candling.

(b) The egg may be broken out of the shell, examined and smelled for odours. This is done where the eggs are to be either dried or frozen as melange, or where they are to be used at once as food.

(c) Quality may also be judged by cooking, baking and whipping tests and by odour and taste.

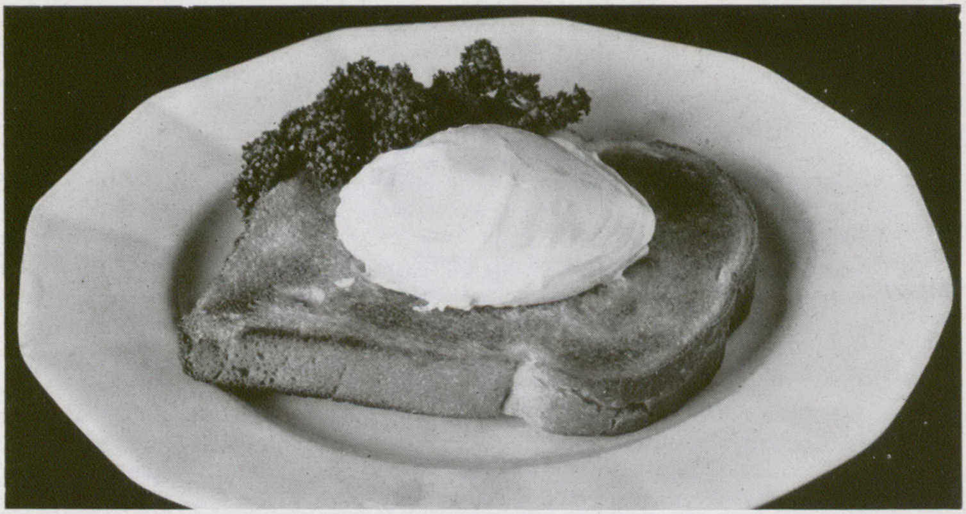


FIG. 3. High quality poaching egg (Grade A).

There are few foods more tempting or satisfying than a perfectly poached egg, attractively served. A poached egg, unbroken and firm, yet delicate and jelly-like in texture is an achievement. The method of cooking is important but the quality of the egg to be poached is equally, if not more, important.

For best results the egg must be of good flavour and the colour of both yolk and white attractive. The yolk must be well rounded (not flattened) and have a strong yolk-membrane. The white must be thick and cling close to the yolk. An egg with a thin, watery white never poaches well. Thus, poaching is a test of quality.

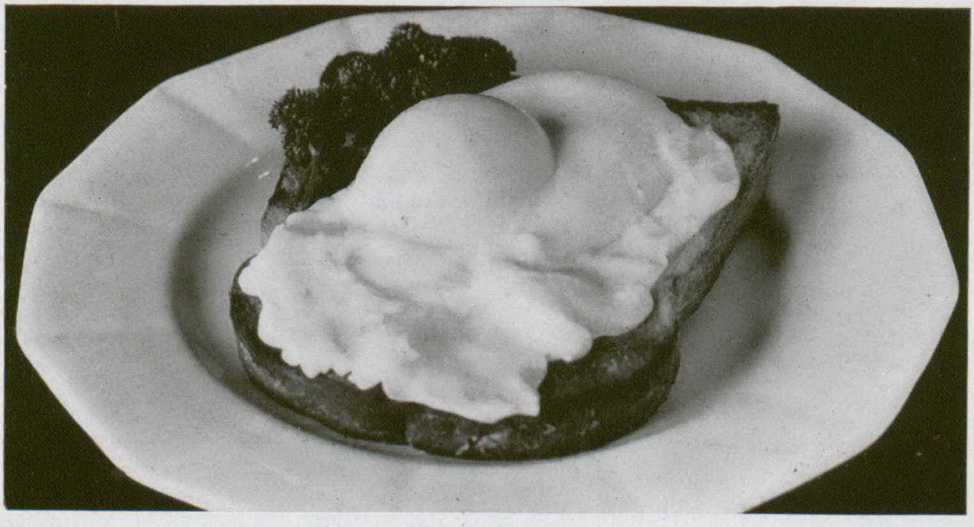


FIG. 4. Medium quality poaching egg (Grade B).

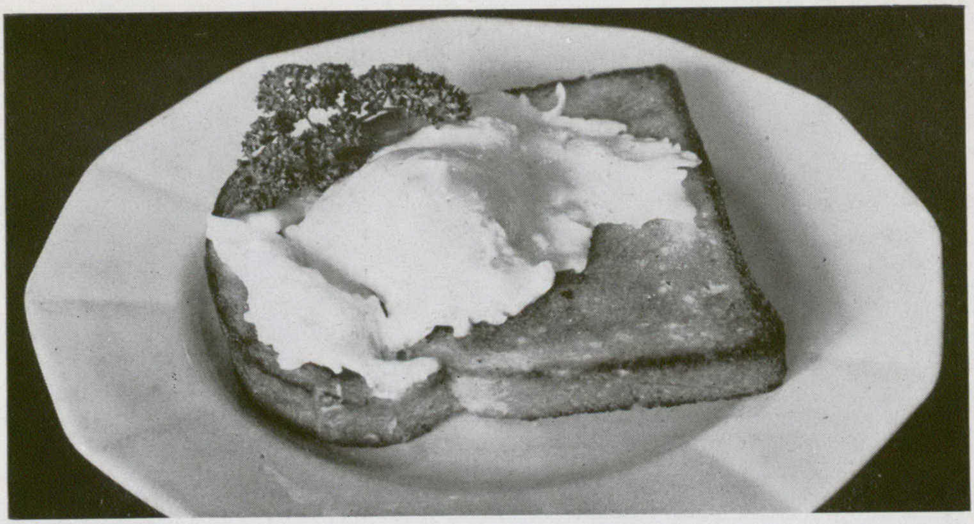


FIG. 5. Poor quality poaching egg (Grade C).

REASONS FOR PURCHASE OF EGGS ON GRADE

The best means by which the customer may be assured good eggs is by purchase on grade. Two main objectives are accomplished by this:

(a) The grade of egg most suitable for the purpose desired is secured.

(b) Economy is easily possible with a minimum sacrifice of food value.

The higher grades are needed for poaching and other purposes where only the best eggs are satisfactory, while the lower grades are suitable for cooking, baking and similar uses.

Grading also remunerates the producer on the basis of the quality produced.

BASES ON WHICH CANADIAN EGGS ARE GRADED[4]

(a) The Size Factor—into large, medium and pullet sizes within the grade.

(b) The Appearance Factor—Grade A1 and Grade A eggs are spotless, while slightly soiled or soiled eggs grade B and C respectively.

(c) The Shell Factor—A poor shell is difficult to handle and results in more rapid spoilage—hence is C grade, especially if cracked.

(d) The Quality Factor—This involves the size of air space; the position, shape, movement and visibility of the yolk shadow when candled; also the thickness of the white and the absence of any germ development and abnormalities such as meat and blood spots.

Every producer and consumer should be familiar with Canadian egg grades and their requirements, and should sell and purchase respectively only on a graded basis. Grading protects both the producer and the consumer and engenders confidence, mutual respect and good will in merchandising.

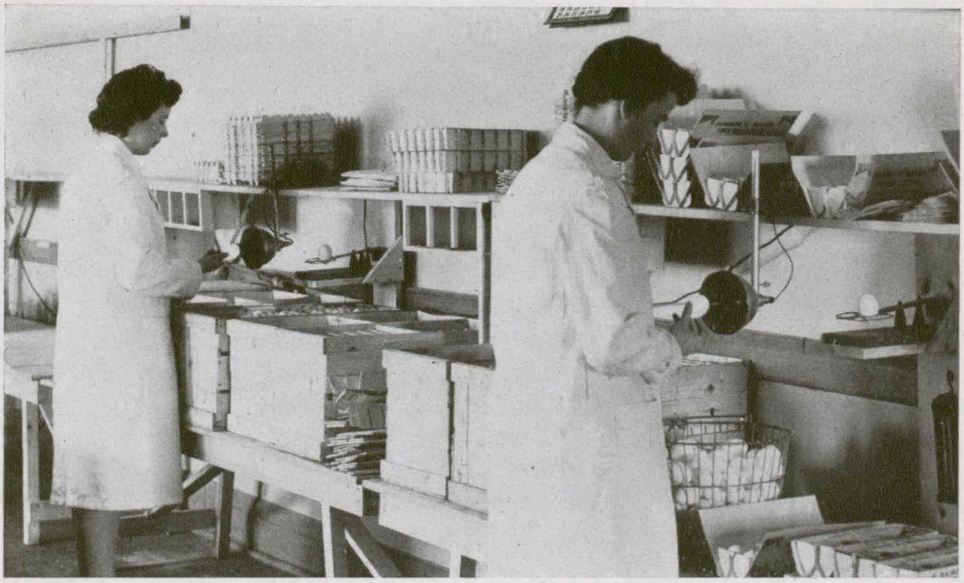


FIG. 6. Set-up and equipment suitable for grading and packing eggs either in cases or in cartons.

Throughout Canada are numerous strategically located Registered Egg Grading Stations. These are equipped to handle and grade the producers' eggs rapidly, accurately and economically. Modern candling lamps and mechanical grading machines are an aid. Cleanliness and controlled optimum temperature and humidity are required by Federal authority as an aid in retaining original quality. Thus, producers and consumers alike are afforded protection.

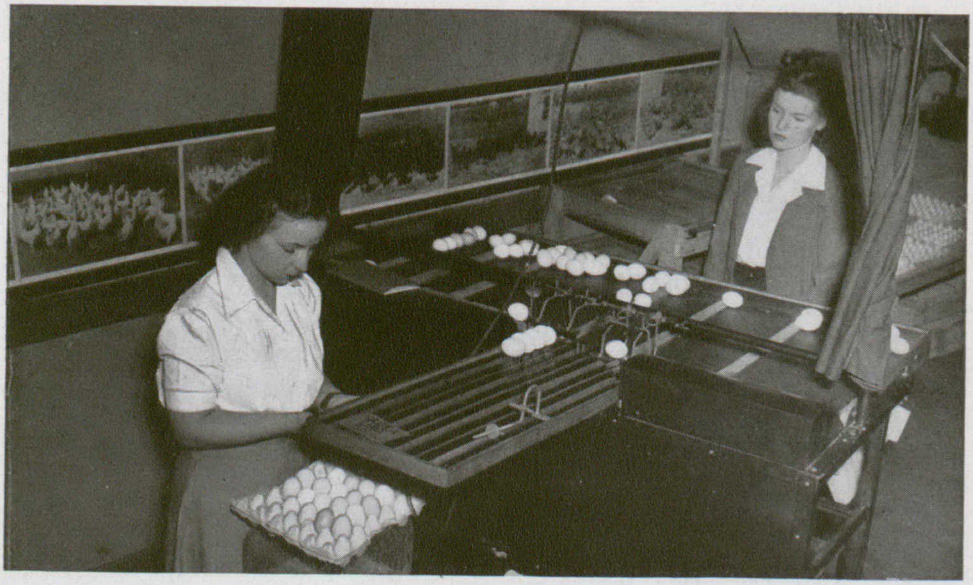


FIG. 7. Egg weight may be determined by sense of touch, checked by the use of scales as in Figure 6, or by machine. This modern machine weighs rapidly and accurately.

TABLE 6 — THE CHIEF SPECIFICATIONS OF THE CANADIAN EGG GRADES[4]

	Shell and Grade Appearance Factors	Weight Per Dozen	Air Cell	Yolk Condition	Undergrades at Point of Shipment	Miscellaneous
A 1	Clean. No spots or stains. Sound. Regular in construction. No cracks or checks.	Large — 24 oz. + Medium—22-24 oz. Pullet — 20-22 oz.	Not to exceed ⅛ inch in depth.	Yolk shadow indistinct, small and round in shape. Well centred. No mottled yolks, grass yolks, germ spots, meat or blood spots allowed.	Not more than 8 undergrades per 15 dozen.	Packed only by producers and producers' organizations authorized by the Dominion Government.
A	Clean. No spots or stains. Sound, regular. No cracks or checks.	Large — 24 oz. + Medium—22-24 oz. Pullet — 18-22 oz.	Not to exceed 3/16 inch in depth.	Yolk outline indistinct. Reasonably small and round in shape. Well centred. No mottled yolks, grass yolks, germ spots or meat or blood spots allowed.	Not more than 8 undergrades per 15 dozen.	Fresh eggs. Best commercial grade.
B	May show slight stains and small spots. Sound. No cracks or checks.	Large — 24 oz. + Medium—22-24 oz. Pullet — 20-22 oz. When commercially packed at one weight —no individual egg below 22 oz. per dozen allowed.	Not to exceed ⅜ inch in depth. No floating air cells.	Yolk outline may be slightly visible, yolk shadow slightly oblong but not definitely enlarged or flattened. Yolk—not at top of egg. Must float freely on twirling. No extremely mottled or grass yolks, pronounced germ spots, blood or meat spots allowed.	Not more than 8 undergrades per 15 dozen.	Cold stored eggs included in this grade.
C	May be dirty or stained. May be cracked or irregular. Cracked eggs packed separately and marked: "Grade C Cracks"	No minimum weight. Note: In Grades A-1, A and B, individual eggs must be up to minimum weight, and up to but not including maximum weight in each weight bracket.	No maximum air cell size.	Outline may be distinctly visible, **but** No yolks adhering to shells. No broken yolk membrane allowed. Extremely mottled yolks, grass yolks, pronounced germ spots and meat spots allowed.	Not more than 8 undergrades per 15 dozen.	Cold stored, small and held eggs included in this grade.

STRUCTURE OF THE EGG

The egg is comprised of five main parts, namely, the shell, the two shell membranes, the white, the yolk and the germ spot or germinal vescicle.

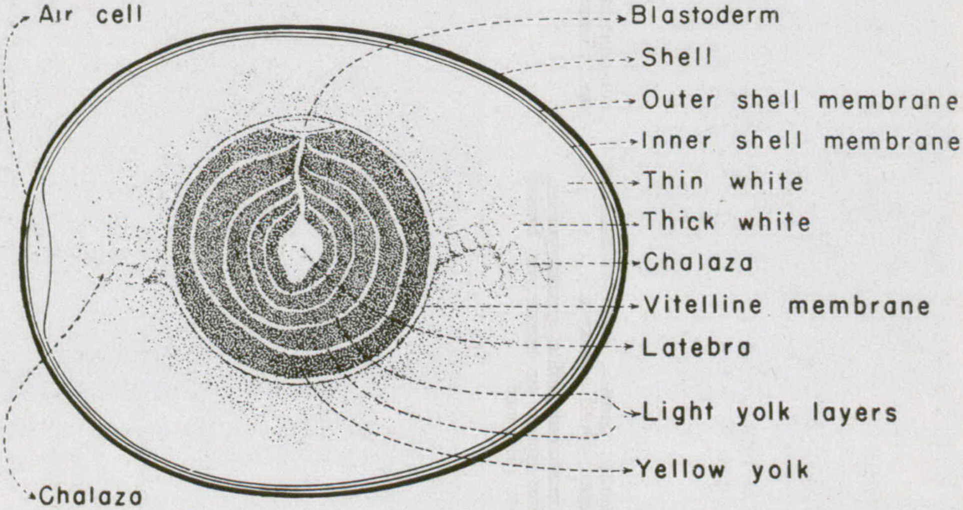


FIG. 8. Structure of an egg.

The Shell—The shell with adhering membranes consists of the mammilla layer, the spongy layer, the pores, the cuticle or bloom and the two shell membranes.

The Shell Layers—The mammilla and spongy layers consist respectively of differently shaped and arranged particles of calcium carbonate, the spongy layer (the outermost) being the thicker and comprising about two-thirds of the total shell thickness.

Pores and Cuticle or Bloom—The pores are more or less irregular minute openings in the shell serving for the purpose of gas interchange during incubation; while the cuticle or bloom, a protein material known as keratin, covers the outside of the shell and, in a freshly laid egg, closes the pores. The reaction of carbon dioxide (CO_2) escaping from the egg with water vapour in the air, serves to gradually dissolve the bloom, thus allowing evaporation of moisture through the pores of the shell when the egg is held or stored.

The Shell is Fragile—The purpose of the shell is to give protection to the fertilized egg and its surrounding food supply during incubation. In this function it is usually efficient and its porosity allows for needed gas interchange for the developing embryo.

The shell was, however, never intended for commercial use. It is not constructed to withstand the rough handling to which it is often subjected in commerce, and its many pores allow for rapid evaporation and also for

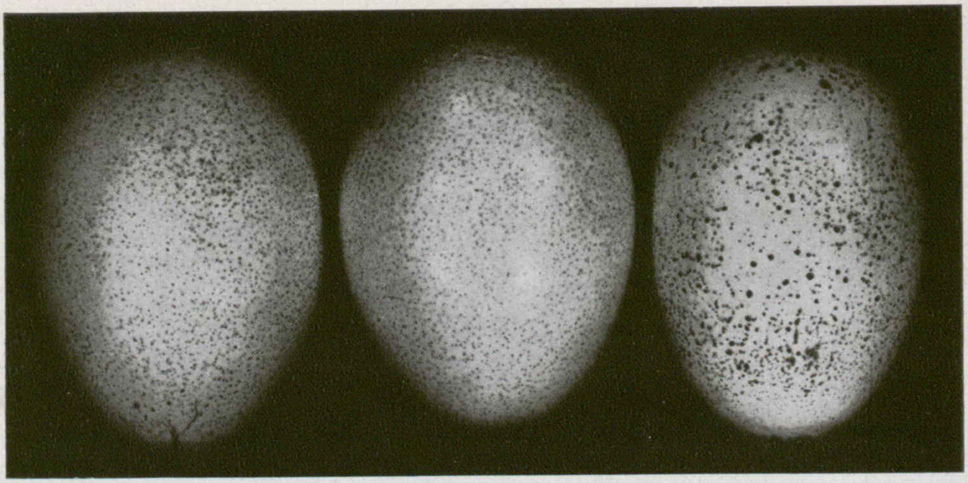


FIG. 9. Two strong, dense shells and a weak, porous one. The shells were scraped on the inside and filled with dye. The dye working through made the location of the pores plainly visible. The larger pores and the more open structure of the weak-shelled egg allowed the dye to work through more readily. There are from about 6,000 to 8,000 pores in an average egg shell. There is a definite tendency for the air space to increase more rapidly in a thin, weak-shelled egg because of greater evaporation from the larger pores in the shell of such an egg.

absorption of undesirable odours. It is for these reasons that eggs should be handled gently and should at all times be kept clean and away from musty conditions and pronounced odours.

TABLE 7—COMPOSITION OF THE EGG SHELL

$CaCO_3$ (Calcium)	93.7 %
$MgCO_3$ (Magnesium)	1.39 %
P_2O_5 (Phosphorus)	.76 %
Organic Matter	4.15 %

G. F. Stewart, Cornell Univ. 1935.

Shell Colour—Shell colour is dependent on the presence of pigment-secreting glands or mechanism among the shell secreting glands of the uterus, that part of the oviduct in which the shell is formed. Breeds and varieties laying white shelled eggs lack this mechanism, hence the calcium carbonate of which the shell is chiefly composed is chalk white. In breeds laying coloured shells, the intensity of colour probably depends on the number, kind and activity of pigment-secreting glands present in the uterus of the individual bird. It should be emphasized that shell colour has no connection with either flavour, nutritional values or keeping qualities of eggs.

Shell Membranes—The shell membranes each consist of a more or less unorganized matrix of organic fibres. The two membranes adhere closely and together line the inside of the shell. Following laying, cooling of the egg results in contraction of the contents. This creates a slight vacuum and results in the parting of the shell membranes usually at the large end of the egg, thus producing the air space which increases in size as evaporation of the egg contents takes place. The shell membranes are not impervious either to gasses or micro-organisms.

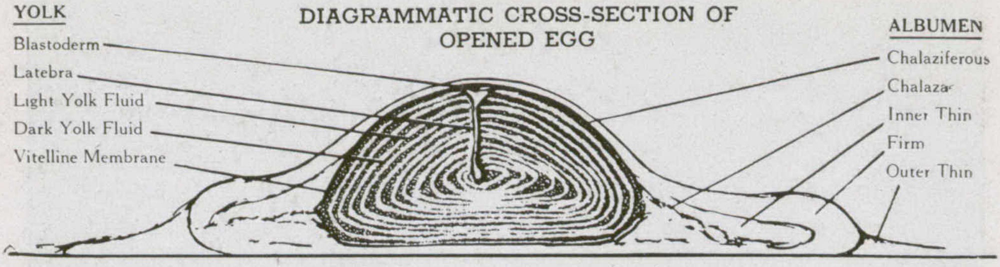


FIG. 10. Note the thin white inside the layer of firm or thick white.

The Egg White—The white of the egg appears to consist of two fractions, thick and thin. Careful examination, however, reveals four fractions, the outer thin and a layer of inner thin, contained within the layer of thick white, but easily released by puncturing this thick white. Also a thin layer of thick white surrounds the yolk and branches out on opposite sides of the yolk to form the twisted cord-like chalazae. These latter help to hold the yolk in a central position within the egg.

The Yolk—The yolk consists of alternate layers of dark and light coloured yolk material surrounded by a containing yolk or vitelline membrane. Yolk size may vary somewhat between breeds and also between individual hens. It also varies with maturity.

The Germ Spot—The germ spot or blastoderm present in every egg, lies on the surface of the yolk just beneath the vitelline membrane, and at the apex of the latebra. (Figs. 8 and 10). This is the point at which, in a fertile egg, the chick embryo commences its development. In a freshly laid or any other good egg the germ spot is inconspicuous, and shows no enlargement or development.

TABLE 8—COMPOSITION OF AN EGG

	The White*	The Yolk*	White and Yolk* Combined	Whole Egg
Water	87.8 %	49.0 %	73.7 %	65.5 %
Protein	10.0 %	16.7 %	13.4 %	11.9 %
Fat	.05 %	31.6 %	10.5 %	9.3 %
Ash	.80 %	1.5 %	1.0 %	.9 %
Carbohydrate	.50 %	......	.30 %	11.2 % (shell)

* R. V. Boucher, Penn. State College.

TABLE 9—THE EGG PARTS

Yolk	32.75 % of total egg	Shell Membrane	.25 % of total egg
White	57.01 % of total egg	Shell	9.99 % of total egg

TABLE 10—SECRETION OF ALBUMEN (EGG WHITE)

Section of Oviduct	Approx. Length in Centimeters	% Albumen Secreted	Approx. Time Spent by Yolk
Mouth	5.0	....	....
Funnel	4.0	....	18 mins.
Magnum	33.0	40-50 %	2 hrs., 54 mins.
Isthmus	10.0	10 %	1 hr., 14 mins.
Uterus	12.0	40-50 %	20 hrs., 40 mins.
Vagina	12.0	....	....

Data of Warren and Scott, 1935. Asmundson and Burmester, 1935.

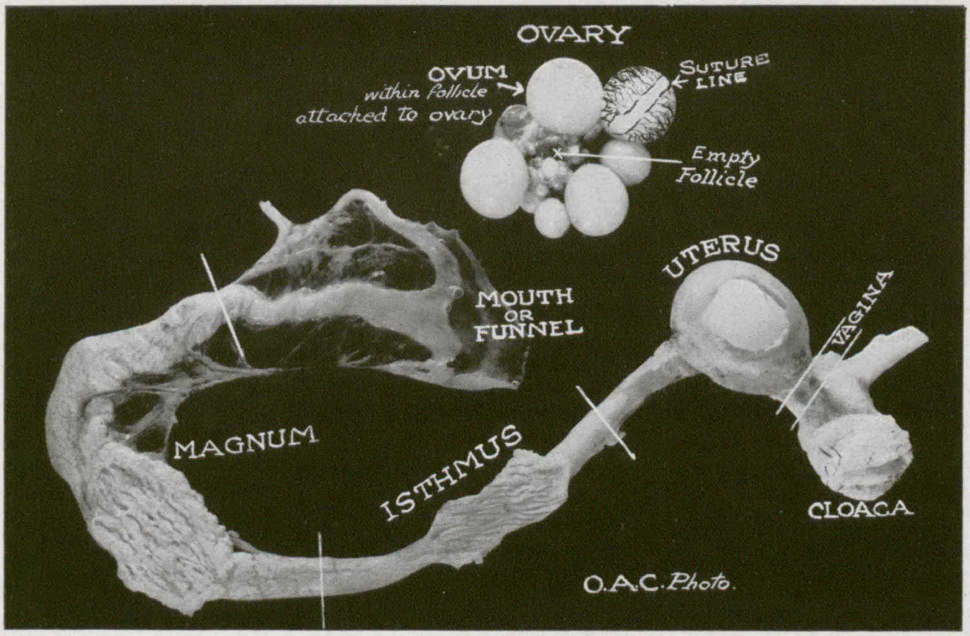


FIG. 11. The mouth or funnel receives the ovum or yolk as it is released from the sac or follicle in the ovary by a rupture of the suture line when the yolk has attained full size. The glands lining the magnum, isthmus and uterus secrete the various parts which, added to the yolk, comprise the complete egg.

PRODUCTION OF AN EGG

The time interval between the ovulation or freeing of the yolk from the ovary to the laying of the completed egg varies from about 23 hours to as much as 30 hours. Table 10 lists the time spent by the yolk and its accruing additions in the various parts of the oviduct. Specialized glandular structures in each section of the oviduct serve to secrete the several parts of the eggs as illustrated. In addition the glands of the isthmus secrete the shell membrane, while those of the posterior part of the uterus secrete the shell. An interesting feature is the secretion of much of the albumen following the formation of the shell membranes. This albumen is absorbed through these membranes by osmotic action and this serves to completely plump the egg prior to the development of the shell.

As illustrated in Fig. 11, the glands of the oviduct are so placed (like the rifling in a gun barrel) as to rotate the "egg" while passing down its length. This rotary movement is a factor in producing the chalazae and in causing the one to be coiled clockwise and the other counter-clockwise.

Both the ovary and oviduct receive a generous blood supply while birds are in laying condition and it is this supply that furnishes the material from which these organs secrete all of the various parts of the egg.

Most eggs are laid small end first.

FACTORS INFLUENCING EGG QUALITY

Quality in eggs is influenced by a number of factors. Some of the more important being: Breeding; Feeding; Seasonal Influences; Management; Physiological Disturbances; Physico-Chemical Changes; Sanitation, Time, Temperature and Humidity.

Effect of Breeding on Egg Quality and Appearance

There are at least five inherited characteristics that definitely influence egg quality and appearance, namely, egg size, egg shape, shell colour, shell thickness and texture, and interior quality. Because these are inherited, any worth-while or permanent improvement of any or all of these characteristics can only be secured by means of a carefully controlled system of selective breeding.

Such selective breeding may readily be carried on by anyone willing and able to spend the time and effort necessary to do the work. Unfortunately relatively few poultrymen are in a position to do so. Also the great mass of farmers and poultrymen purchase their supply of baby chicks yearly from hatcherymen. Mating the supply flocks of these hatcheries with males progeny-tested for known egg quality factors would seem then the most practical means of mass improvement along these lines.

(a) **Egg Size**—Rapid improvement may readily be made in the average egg size of a flock by using breeding males whose sisters and daughters produce eggs of the desired size. The following chart (1) demonstrates the effectiveness of such selective breeding.

Data reported by the Poultry Division of the Central Experimental Farm, Ottawa, indicate a considerable degree of correlation between egg size and bird size within a given variety. Reports from other experimental stations, and from the Ontario Agricultural College all tend to support this fact. The setting of pullet eggs weighing 24 ounces or more will, over a period of several years, result in improved egg size from the flock. To secure comparable results with hen eggs, only eggs weighing about 25½ ounces or more per dozen should be used. Pullets laying eggs weighing 23 to 23½ ounces per dozen, may as hens lay eggs over 24 ounces per dozen in their second year, though many are inherently breeders of small eggs.

(b) **Egg Shape**—None but normal shaped eggs should be incubated. Eggs too long or too round in shape are difficult to pack commercially without excessive breakage. They are also unattractive in appearance when exposed for sale. While it is difficult to achieve perfection, considerable improvement generally follows careful selection for shape of the eggs set.

(c) **Shell Colour**—Egg shell colour is entirely dependent on the breed. Some breeds such as the Leghorn lay white shelled eggs while others such as the New Hampshire lay brown or tinted eggs, the difference depending on the presence or absence of a pigment-secreting mechanism in the uterus where the shell is secreted. Needless to say, shell colour has no influence whatsoever on interior egg quality, as the shell is the last part of the egg to be formed.

(d) **Shell Texture**—Shell texture is important in the handling of eggs and in regard to eye appeal. While shell texture is influenced by the diet, some birds appear to lack the ability to produce strong, dense shells, even when all known shell-forming ingredients are available in the ration, thus indicating heredity as a factor.

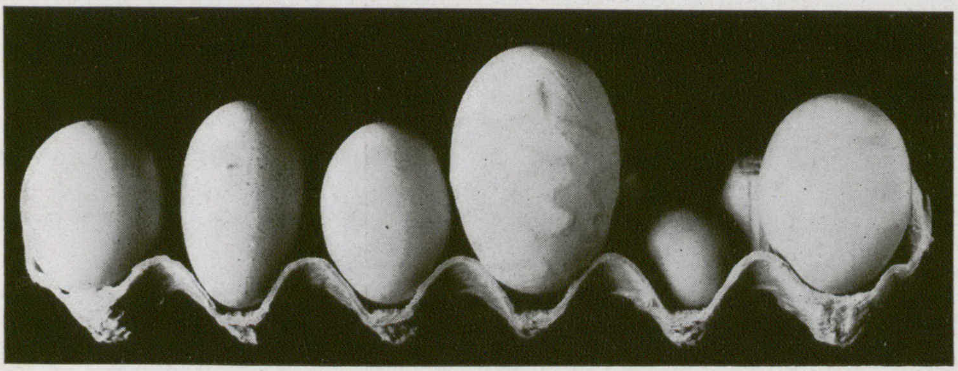
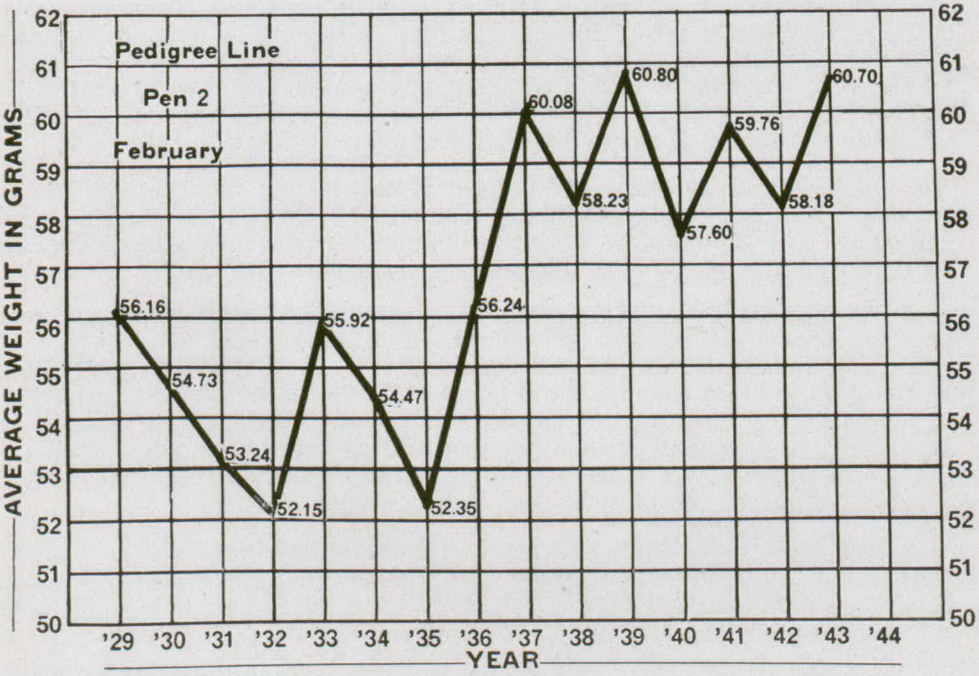


FIG. 12. Eggs of undesirable shape and size lack eye appeal. Compare with Figure 2.

CHART 1—EFFECT ON EGG SIZE, OF BREEDING AND SELECTION IN BARRED PLYMOUTH ROCKS



(Original)

CHART 1. Selection for egg size was initiated in 1935. Some variation in size from year to year is unavoidable. A two-ounce egg weighs 56.7 grams.

(e) **Interior Quality**—The percentage of thick and thin white often varies considerably in the eggs laid by a given flock, even where a finely ground all mash ration is the only source of feed. Various research workers have found this to be an individual characteristic of birds very little influenced by feed. It has also been found that eggs having a high percentage of firm white when laid, liquefy less rapidly in storage than those with less thick white. In view of these findings it would seem wise to breed from individual birds, families and flocks that produce eggs containing a large percentage of thick white. Candling eggs prior to hatching is helpful, but the use of pedigreed breeders, especially males whose dams, granddams and sisters exhibit this quality, will produce much more encouraging results.

There are indications that the strength of the vitelline or yolk membranes in eggs is also an inherited characteristic.

Carefully conducted, well organized breeding projects, incorporating all of the foregoing factors should then offer definite possibilities for improving the quality of eggs laid by Canadian flocks. Hatcherymen and breeders alike may be well advised to explore these possibilities.

Effect of Feeding on Egg Quality

Feeding affects eggs in several ways. It affects the food value, the quality of the shell, the colour of the yolk and white, the keeping quality in storage and the flavour.

The extensive literature on egg quality contains numerous well-authenticated evidences of the effect of feed on eggs. The amounts of such vitamins as A, B, riboflavin and D present in eggs are definitely affected by the feed and can be varied to a considerable degree at will, dependent on the amount of these vitamins in the rations. The content of other vitamins, excepting C, is probably also similarly affected.

(a) **Mineral Content**—It has been demonstrated that the addition of cod liver oil to a ration increased the amount of both iron and copper in the egg yolk. The amounts of iodine, silenium, fluorine and other minerals found in eggs have also been increased by feeding.

(b) **Shell Quality**—Apparently at least four feed factors are involved, namely, vitamin D, calcium, phosphorus and manganese[5]. A shortage of vitamin D results in thin shelled eggs and the same is true if insufficient oyster shell or other calcium supply is fed. While there is little phosphorus in egg shells, it is a factor in the balance of minerals and vitamin D necessary for good shell production. One half pound of manganese sulphate per ton of mash where equal amounts of grain and mash are fed, or one quarter pound per ton of total feed fed, is ample.

For best results then, vitamin D, (or direct sunlight), calcium, phosphorus and manganese should be supplied to the layers and in proper balance. The occasional bird which, even on a good diet, habitually lays eggs with poor shells should be slaughtered for food.

(c) **Colour of Yolk**—Yolk colour is an important factor in securing eye appeal of eggs as food. This colour is directly dependent upon the feed consumed by the hen. Carotenoid pigments, such as xanthophyll, zeaxanthin, crytoxanthin and more rarely capsanthin are the pigments involved, the first two being most common. Green feeds such as alfalfa, clovers and grasses, certain weeds such as shepherd's purse and penny cress, yellow corn, carrots and similar materials serve as the source of such pigment in egg yolks. Therefore, control of the amount of pigment carrying feeds in the ration will serve to produce the shade of yolk colour most desired. Limiting access to range will serve the same purpose. Layers should not have access to a wet, boggy barnyard if eggs of superior quality are desired,

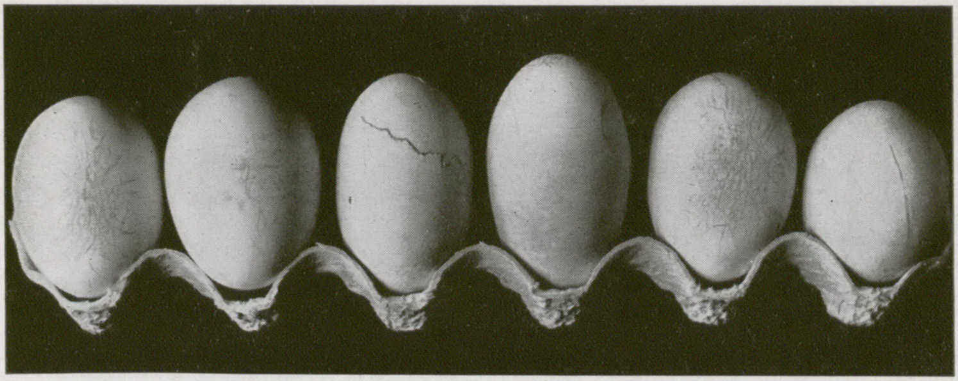


FIG. 13. Such eggs should be used on the farm to avoid breakage and loss during marketing.

as material consumed here may produce undesirable yolk colour and also undesirable flavour. While eggs of superior storage quality are produced in the spring when the flocks are on range, a considerable percentage of them may have yolks too deeply coloured to be included in Grade A. Confinement of the flock during the forenoon and allowing free access to a good laying mash as well as continued feeding of hard grain will largely prevent excessive yolk colour. Depth of yolk colour may or may not be an indication of nutritional value. Cod liver oil may serve as a source of vitamin A without the use of green feed.

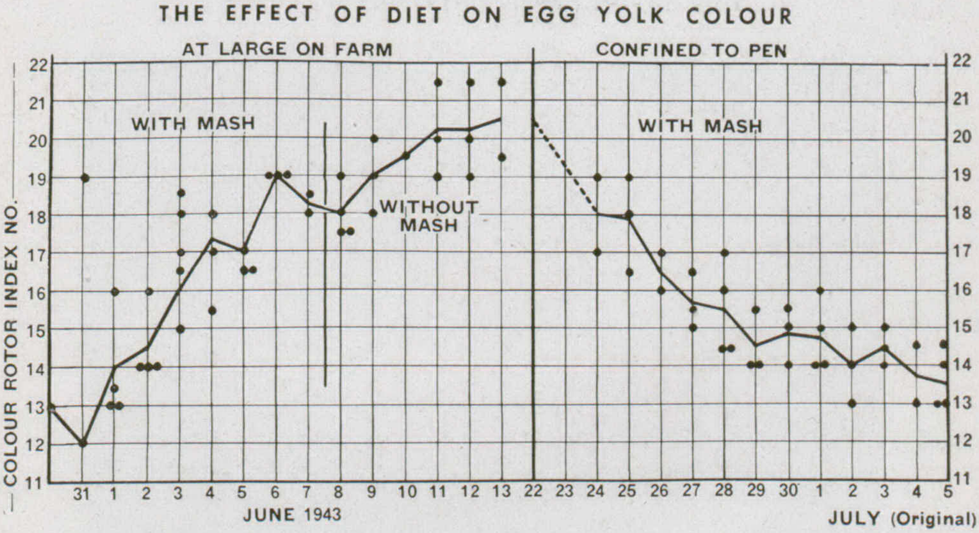


CHART 2. Pullets laying lemon yolked eggs (rotor Nos. 12 to 14) under confined housing and controlled feeding, when moved to a farm and on range (Fig. 18) but fed the same feeds, quickly produced darker yolks, (Fig. 16) (rotor Nos. 19-22), especially when deprived of mash. When again returned to the original quarters and method of feeding, yolk colour returned to the lemon shade.

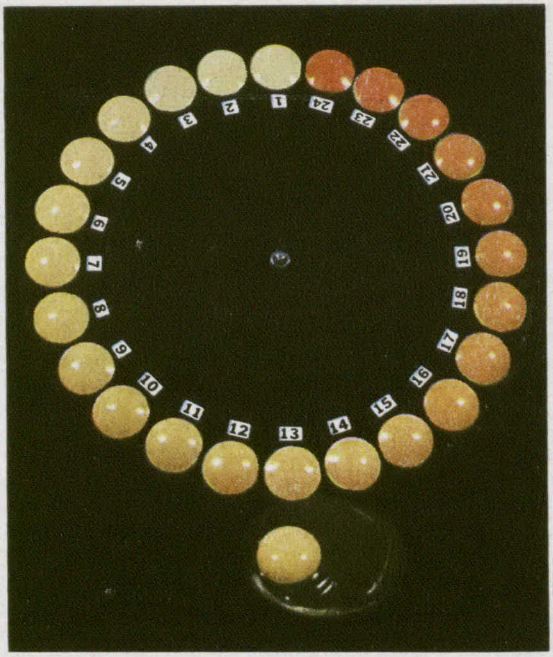


FIG. 14. Colour Rotor — a device used for measuring yolk colour. There are 24 colour gradations ranging from a light cream, No. 1, to a dark orange red, No. 24.

FIG. 15 — LEMON COLOURED YOLKS

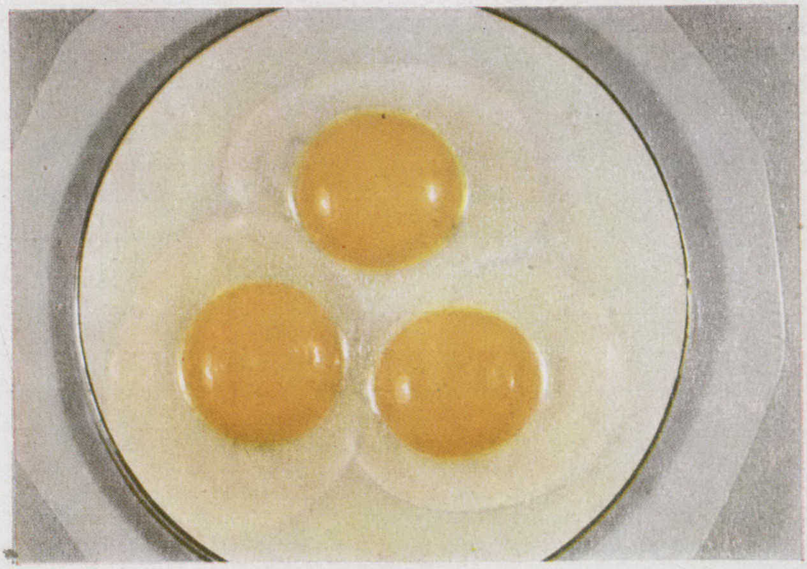


FIG. 15. Confinement and controlled feeding of a balanced ration and a moderate amount of green feed result in moderately light uniformly coloured yolks.

FIG. 16—DARK COLOURED YOLKS

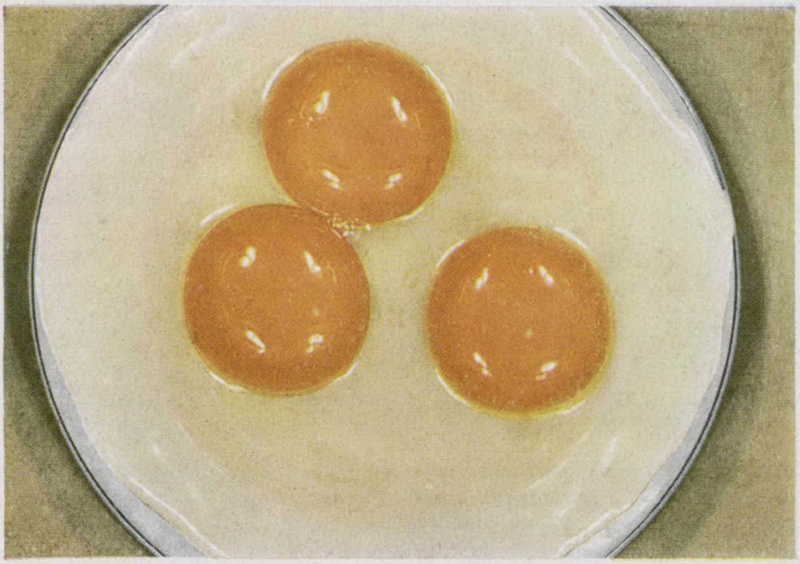


FIG. 16. Excessive green feed or other pigment carrying materials consumed by layers and uncontrolled feeding and management are factors affecting the depth and uniformity of yolk colour.

FIG. 17—MIXED COLOURED YOLKS

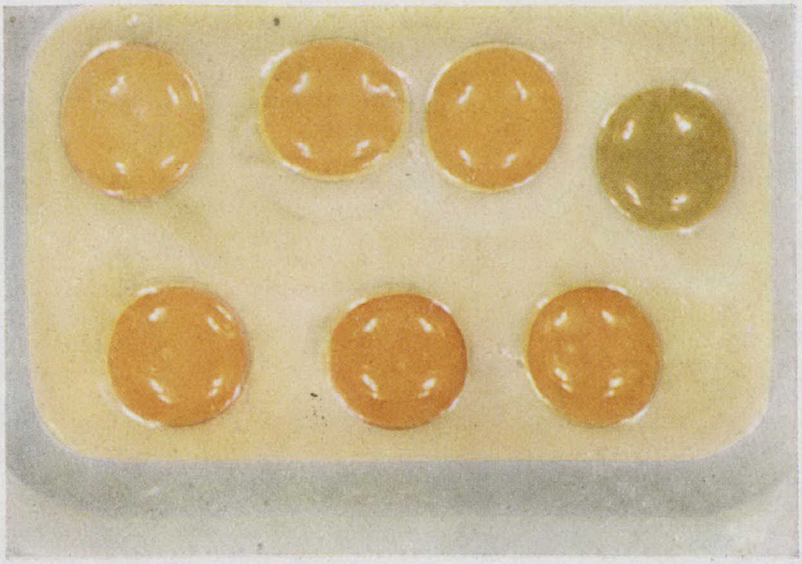
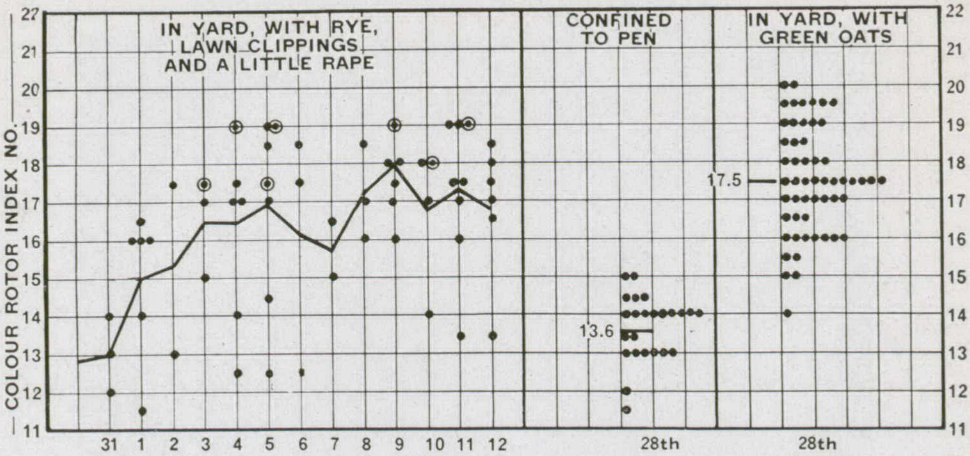


FIG. 17. One day's eggs from a pen of layers under uncontrolled feeding. See Chart 3. A platter of poached eggs having uniform yolk colour has much more "appetite teasing" eye appeal than one varying greatly in this respect.



THE EFFECT OF DIET ON EGG YOLK COLOUR

CHART 3. (a) Pullets laying uniform lemon yolked eggs, when allowed outside in a yard seeded to rye and a few rape plants laid eggs with a wide variation in yolk colour (rotor Nos. 12 to 19) and also within four days laid olive green yolked eggs. (Dots with circles). (b) Comparison by scatter diagrams of the yolk colour of eggs laid on July 28th by two pens on the same feed but different management.

(d) **Colour of Egg White**—A comparatively new but interesting development is the recognition that riboflavin (vitamin G) is indicated in the whites of eggs by a yellow-green coloration. The depth of this colour in eggs varies considerably and is a fair indication of the amount of the vitamin present. It is also now recognized that the depth of colour varies with the riboflavin content of the ration, irrespective of the source, whether natural or synthetic. It is known that the riboflavin content of eggs varies rather widely. Within certain limits this condition is controllable. The feeding of adequate levels of such common riboflavin carriers as milk by-products, liver meal, alfalfa meal and young grasses, results in the production of eggs of high riboflavin content.

(e) **Keeping Quality in Storage** — Under normal conditions a considerable percentage of the spring months' egg production must be stored. Eggs produced from well-balanced rations, which are then quickly cooled and properly stored, largely retain their original quality even after six to nine months in storage. Certain feeding materials may, however, considerably lower the keeping quality. Among such are cottonseed meal, mallow and the feeding of much green feed with an unbalanced ration.[6] Pink, brown and green storage discoloration, particularly of the yolks, often follows access to such material, the extent of discoloration being largely dependent on the amounts fed. If cottonseed is fed at all the amount included in the total ration should be small. Cottonseed contains gossypol and this causes the yolk discoloration.

(f) **Flavour** — The flavour of eggs may be influenced by feeding. Flavour and odour are closely associated and are usually more evident after cooking than before. Such feedstuffs as onions, rape, turnips and some fish meals and fish liver oils have all been reported to produce off-flavoured eggs, when fed in excessive amounts. Excessive consumption of grasshoppers and other insects may have a similar effect. The best flavour results from the feeding of sweet and clean grains and their by-products, supplemented with high-quality animal and vegetable proteins. To these may be added moderate amounts of green feed.

(g) **Water Consumption** — Water consumption influences egg size; lack of adequate supply resulting in decreased size and also in lowered production. A continuous supply of clean fresh water, cool in summer and slightly warmed in winter, encourages maximum consumption.

(h) **Scavengers** — Inducing the layers to become scavengers by withholding laying mash during spring and summer often results in the consumption of excessive amounts of green feed and other material. Such practice may quite easily adversely affect the colour and flavour of the eggs produced, particularly if the hens are kept under unsanitary yard and range conditions. Such management results in lowered quality of many eggs and is, therefore, wasteful and uneconomical.

Effect of Seasonal Influences on Egg Quality

The appearance of eggs is greatly influenced by the weather as found in the different seasons of the year. Many more eggs become soiled during the wet spring and fall weather than during the summer and winter. One investigator found 9.8 per cent of soiled eggs produced in July as compared with 24.6 per cent in March.[7] During wet weather yards become muddy and litter becomes wet and soiled. This results in dirty feet. Soiled eggs are the natural consequence when the birds enter the nests to lay.

During those seasons when birds are outdoors and green feed is plentiful, more of this feed as well as other possibly undesirable material is consumed than when confined. While the resultant eggs producd may be of high hatchability, the palatability and broken-out appearance is often less desirable than that found in eggs produced in confinement.

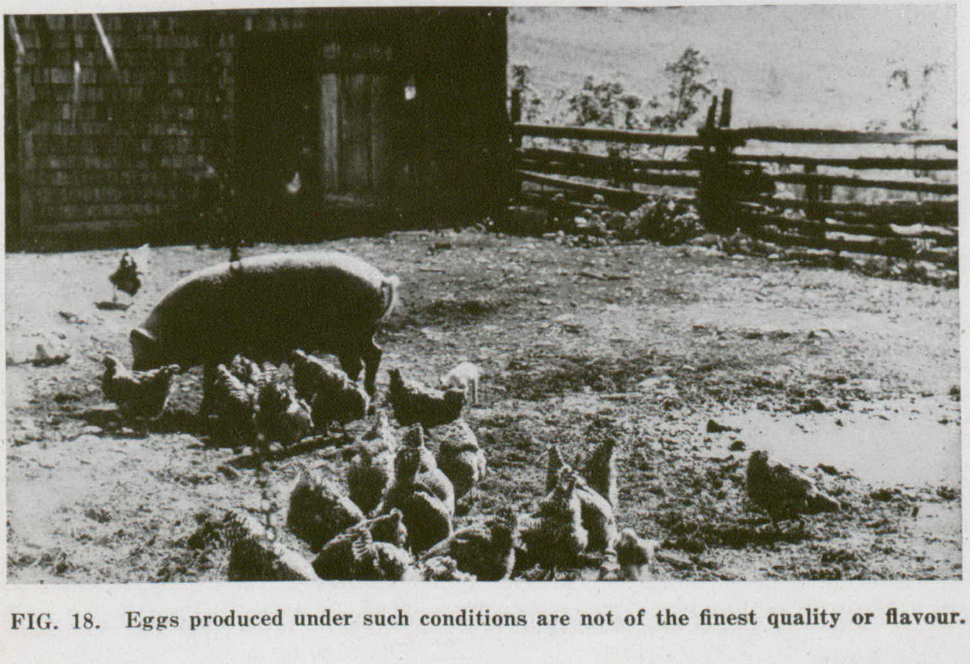


FIG. 18. **Eggs produced under such conditions are not of the finest quality or flavour.**

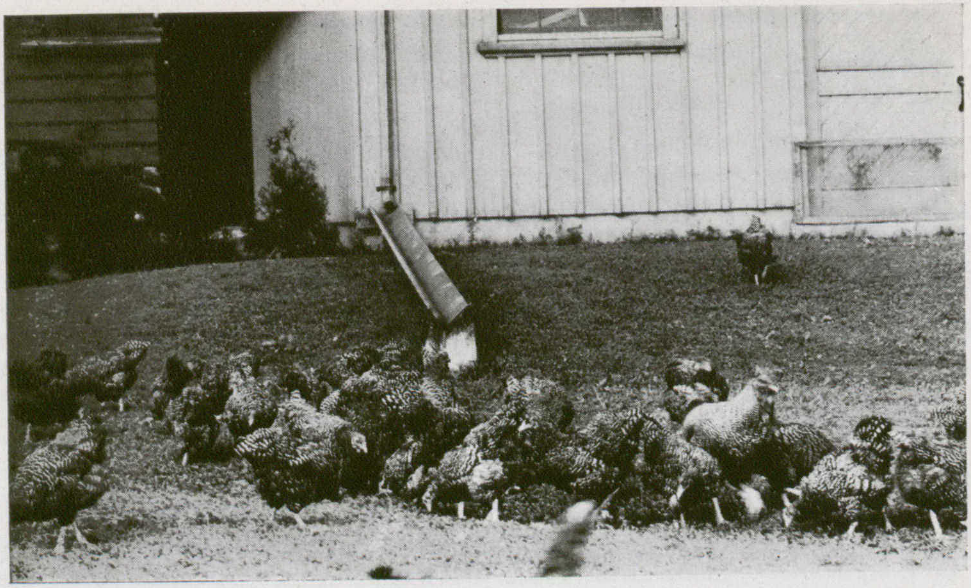


FIG. 19. Eggs from hens receiving plenty of mash and grain and a moderate amount of clean, short pasture are usually of excellent quality.

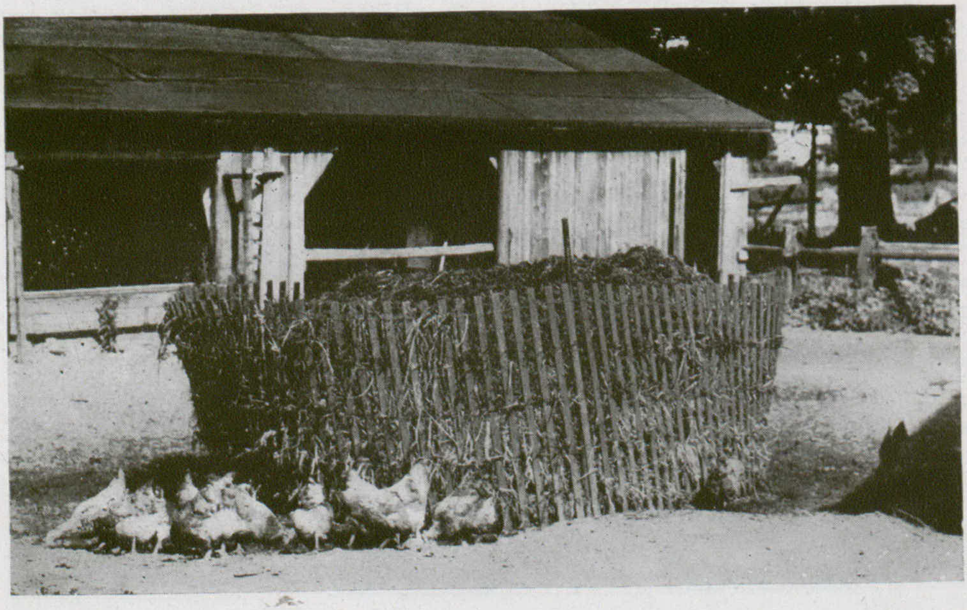


FIG. 20. One means of keeping layers from manure and other refuse.

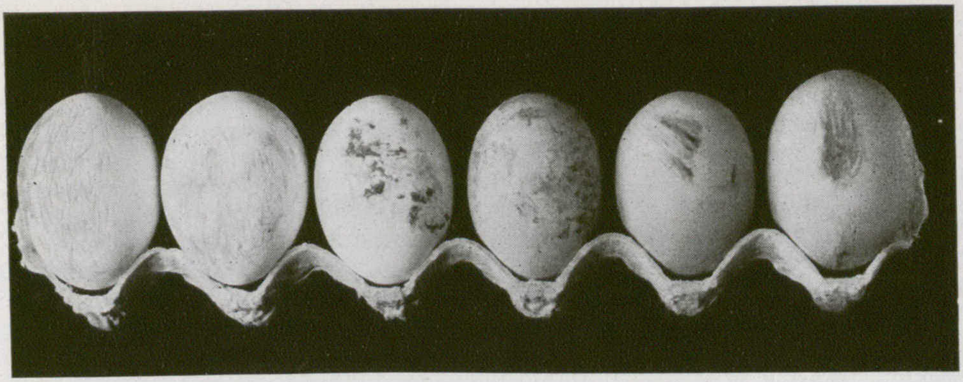


FIG. 21. Slightly soiled eggs are Grade B, and heavily soiled, Grade C (two in centre). Compare with Figure 2.

Cleaning Eggs — There seems to be no way of entirely eliminating soiled eggs. Brown shelled eggs do not show slight soiling as readily as do chalk white ones, but it is there nevertheless. Even after taking the greatest practical precautions it has been difficult to reduce soiled shells below from five to six per cent. Soiled eggs are unattractive and produce sales resistance on the part of the buyer. This can only be overcome by lowering the price. This consumer reaction is relative and is overcome by grading slightly soiled eggs B and badly soiled ones C grade, the producer absorbing the loss.

Every effort should be made to produce clean eggs. The loss from soiled eggs can, however, be partly prevented by cleaning. This can be fairly satisfactorily done in several ways. A clean moist cloth will remove slight stains easily. The use of a little acid such as vinegar, or alkaline material such as washing soda, will help dissolve and remove dirt. Steel wool may also be used, or a buffer made out of a sheepskin shoe polisher over which is fastened a strip of emery cloth. Such abrasives tend, however, to produce shiny spots on the shell.

Machines for cleaning eggs have been developed and produce satisfactory results. They are of two main types, one using whirling loops of emery cloth and the other blasts of sand. Due to their high cost, such machines are economical only on very large poultry farms or at collection points where large numbers of eggs are handled.

Badly soiled eggs should be washed. Such eggs, if stored, do not, however, keep well, chiefly due to the rubbing of filth and bacteria into the pores during washing. Where quantities of eggs are to be washed, either for storing or before breaking for drying or freezing, keeping quality is greatly increased by washing in a solution of sodium hydroxide (common lye).[8] One-half to one per cent of lye is sufficient and the strength must be kept uniform. This may be done by the use of a hydrometer. Rubber gloves are necessary to protect the hands, and the eyes and clothing must also be given protection as lye is very corrosive. Eggs washed in lye solution have been reported to keep as well in storage as clean, unwashed eggs.

A number of investigators have reported a tendency toward a lowering of egg quality as indicated by broken out appearance, with the advent of summer weather. The best quality is reported to occur about February. This difference is reported to be independent of temperature.

Egg shells often tend to decrease in thickness and quality during April and May, and egg size also decreases somewhat at the same time. Usually the largest eggs and the best shell quality are found in late January and February. There is then a gradual downward tendency until late July and August, after which there is again improvement in these respects. The date of hatching and the age of bird may be influencing factors. It appears, however, that less blood calcium is present in the birds' blood in warm weather, resulting in a lower rate of calcium deposition.[9] Cool, comfortable laying houses, secured by good ventilation and insulation are helpful, but it is often difficult to entirely prevent the production of weak shelled eggs at this season. Sometimes extra vitamin D will help, as the birds spend so much time in the shade, out of the sunlight and heat, that additional vitamin D assists in improving calcium assimilation and deposition.

Effect of Management on Egg Quality

Proper management may assist greatly in the production and retention of the highest quality in eggs. Keeping the flock confined away from unsuitable feed and out of unsuitable yards is important. Continual feeding of a good laying mash and grain while birds are allowed to forage outdoors will largely prevent any ill effect on quality from such forage. Confinement during wet days will prevent many dirty eggs.

Keeping the yards and litter dry and clean and screening the dropping boards and pits prevents many dirty eggs. Supplying sufficient suitably placed, clean and well-bedded nests is another important factor, while removal to other quarters of all broody hens and frequent gathering of eggs prevents quality loss and much breakage. Birds should not be allowed to remain in nests overnight.

The feeding of over-laxative feed results in soiled bedding and soiled eggs. Poor drinking vessels also contribute by the wet litter which develops around them. Many eggs become soiled by being handled with dirty or wet hands and by being gathered and stored in dirty utensils.

Eggs should be gathered frequently and cooled quickly. Recent investigations show that measurable albumen quality loss occurs in eggs left in a nest on a hot day, even for so short a time as four hours.[8a] This loss is increased where the egg is sat upon and kept warm by a hen.

Rough handling on the farm and in transit may result in breakage or if less severe, in injury to the air cell and other internal egg structure and so hasten lowered quality. Such damage is increased where eggs are not packed large end upwards. The use of soiled flats and fillers is a factor in the production of musty eggs and rots, especially if the eggs are stored or held in an over-damp, poorly ventilated place. Strong, clean fillers in the egg crates support the eggs better and prevent breakage, some types being superior to others in this respect. Over-large eggs may cause excessive breakage and also the soiling of surrounding eggs. As stated elsewhere, eggs are very susceptible to the absorption of odours and flavours. Storage near tar, coal oil, fish, onions or even oranges may easily result in the absorption of such flavours. For this reason eggs should not be stored in refrigerator rooms where oranges or other fruits have been stored unless the rooms are first deodorized.

Need for proper management is not confined to the producer alone. Due to the great perishability of this product, all persons connected with the industry must practise equal care. Quick cooling, proper storage, correct packing and rapid transfer under optimum conditions from producer to consumer are all equally important in securing maximum results for all concerned.

Effect of Physiological Disturbances on Egg Quality

(a) **Abnormal Eggs and Rejects** — Notwithstanding the variety of conditions under which they are produced, the great majority of newly laid eggs are of excellent quality and attractive as food. There is, however, a small and varying percentage of eggs that are, due to the occurrence of certain abnormal physiological reactions during their development, more or less objectionable. A better understanding of these is helpful to both producer and consumer.

(b) **Blood Spots** — Occasionally eggs are laid containing varying amounts of blood. Such eggs, because of their objectionable appearance, are classed as rejects when graded. Losses from this source range from about one-half to ten per cent or more.

The immediate cause is considered to be a rupture of or leakage from small blood vessels on the follicle or sac in which the yolk or ovum develops in the ovary. Many of these hemorrhages occur between the follicle and the yolk membrane (intra-follicularly). The amount of blood released may be minute or relatively large. Recent research indicates these hemorrhages mostly occur before the yolk is freed from its follicle.[10] It is possible that some occur when the follicle ruptures along its suture line to release the yolk at the time of ovulation. It is also possible that hens with hemorrhagic ovaries from any cause will produce abnormally high percentages of eggs with blood spots.

Possible Causes:

(1) **Heredity** — Some families are much more subject to the production of blood spots than are others, even under identical feed, care and management. This strongly suggests heredity as a factor.

(2) **Over-Stimulation of the Reproductive System** — There are often more blood spots during peak production. Most trouble is experienced in the spring months, some in the fall, less at other times.

(3) **Excessive or Violent Exertion** — This may be brought about by fright, jumping from high perches and similar conditions. It is assumed that the excessive muscle tension reaches all parts of the body including the follicle around developing yolks, and may cause abnormal rupture of suture lines during ovulation. Some recent investigations cast doubt on this theory.[10] The exact cause of blood spots is still in question. Further research is needed as authorities and investigators are still somewhat in disagreement.

(c) **Bloody Eggs** — In such cases the amount of blood is relatively large and is often diffused throughout the white.

Cause — Similar to blood spots, though there is a possibility that some such leakages may occur in the upper part of the oviduct (magnum) where about 40% to 50% of the egg white is secreted.

(d) **Meat Spots** — Recent investigations indicate most meat spots as blood spots in various stages of degeneration due to changes in the blood through oxidation and other factors.[10] The blood colour changes from red to brownish, gradually fading until practically colourless. High temperatures and increased pH (hydrogen ion concentration) have been suggested as contributing causes of this change in colour. Some meat spots may consist of sloughed off ovarian tissue and even small ova. Several of the latter have been observed by the author.

At times these blood and meat spots become a real problem. In a recent investigation by the author a total of 652 eggs laid by 12 pens of Barred Plymouth Rocks were broken out daily as laid over a period of four days. Of this number 17 eggs or 2.6 per cent contained blood spots and 369 or 56.6 per cent contained meat spots, making a total of 59.2 per cent. Only a small number of these were observed by candling as fortunately many of the spots were no larger than specks of pepper.

Eggs with meat spots are not classed as rejects. They are graded into Grade C. This is because their appearance is less objectionable than that of blood spots and they can be readily removed when the eggs are broken out for use as food

(e) **Other Abnormalities — Double or Multiple Yolked Eggs** — About 40 per cent of double yolked eggs result from the ripening and ovulation of two yolks at the same time. These move down the oviduct together and are enclosed in a common shell. The remainder have been reported as mainly due to the failure of the oviduct to "pick up" an ovum until the stimulation created by the ovulation of a second ovum occurs. When commencing to lay, over-stimulated pullets sometimes lay triple or even quadruple yolked eggs.

Eggs containing abnormally large and very cloudy yolks occasionally occur. Others have the white rather jelly-like in appearance or resembling mucous, while still others contain coagulated fibrin. A temporary catarrhal condition or inflammation of the oviduct may be a factor in the production of the latter. Such eggs occur infrequently and are easily candled out. Very small eggs sometimes occur containing a small amount of yolk, a meat spot or a small mass of thick white instead of a normal yolk as their centre. These also are of no value.

Eggs with rough or corrugated shells and others with flattened areas, the latter often checked with poorly repaired cracks, are other abnormalities. (Fig. 13). Over-fatness, with masses of fat pressing against the uterus and heredity are causes, and rough handling of the birds may also be a factor.

Effect of Sanitation, Time, Temperature and Humidity on Egg Quality

(a) **Broken Out Appearance** — Most eggs from flocks under controlled feeding and sound management are high in quality no matter what the basis of judgment. The average consumer reaction depends chiefly on the egg's broken out appearance, which in turn is directly correlated with the appearance when prepared for food, as when soft boiled, poached, fried, hard boiled or whipped. An egg that "stands up" well when broken out, looks attractive and palatable both before and after cooking. In Figures 22, 23, 24 and 25, a series of four eggs is shown that illustrate maximum, high, medium and low quality when judged by broken-out appearance. Critical examination involving the yolk index, the albumen index and careful measurements of thick and thin white makes possible relatively exact measurements of such quality. These yolk and albumen indices are determined by dividing the measured height of each by its mean diameter, the measurements being taken with finely graduated and exact instruments.

A study made at the O.A.C. Poultry Department in 1941, of 1,807 eggs, revealed 1,307 (72.3%) with the appearance shown in Figure 22; 353 (19.5%) like Figure 23, and 128 (7.1%) like Figure 24 or intermediate between Figures 23 and 24. In addition 19 eggs (1.04%) were like Figure 25 except that the majority of the yolks were not quite as flat. The eggs in question were laid by four breeds and were broken out and examined immediately after thorough cooling. The broken out quality varied somewhat with the breed and even more with individual birds within the breed. Other investigators report somewhat similar results.

Not only do eggs vary in quality when laid, but those from individual hens may vary considerably in keeping quality when stored.

In addition to these differences, eggs will change rapidly in broken out appearance from that of Figure 22 to that of Figure 25, dependent upon certain physical and chemical changes, the extent and speed of these changes being in turn dependent upon the factors of sanitation, time, temperature and humidity.

Eggs are never better than when first laid. The longer they are stored, the less desirable in broken-out appearance do they become. High temperatures greatly hasten deterioration. The writer has frequently reduced Grade A eggs to B and even to C grade in one week by storing at room temperature (70°-85° F.). Eggs so held will also show an enlarged germ spot and, if fertile, may even undergo sufficient embryonic development to show blood vessels. Ten days to two weeks of hot weather invariably result in greatly lowered quality of the eggs reaching the market, and, largely because of this, also in a considerably reduced consumer demand. This lowering of quality can and should be prevented as decreased demand results in lowered price to the producer.

Physical and Chemical Reactions That Lower Egg Quality

High-grade eggs contain a high percentage of firm or thick white. The proportions of fluid and firm white in eggs varies considerably and this variation appears to be chiefly due to hereditary factors rather than to the diet. The outer fluid white has been reported to comprise 20 to 55%, the firm white 27 to 56%, and the inner fluid white 11 to 36% of the total egg white.[3] A number of reactions take place in eggs during the interval between laying and consumption. Some of these are physical, some chemical and others a combination of the two. As a result of these reactions the air space increases in size due to loss of moisture through evaporation and the weight of the egg decreases; the white tends to thin and decreases in amount and becomes increasingly alkaline. The yolk increases in size, the yolk membrane becomes weakened and easily ruptured and the yolk flattens when broken out.

When freshly laid the egg contains approximately .5% of carbon dioxide, (CO_2). The thick white at this time appears rather cloudy or opaque, particularly if cold, but soon becomes clear. Holding results in a gradual loss of CO_2 and with it a loss of the original "fresh" flavour. This is quite apparent in an egg stored for several months. The loss of CO_2 also affects the hydrogen ion concentration or pH of the egg, resulting in increased alkalinity; the freshly laid egg having a pH of about 7.6 while that of a held egg may rise to 9.5 or higher. This represents an increase in alkalinity of about 80 times.

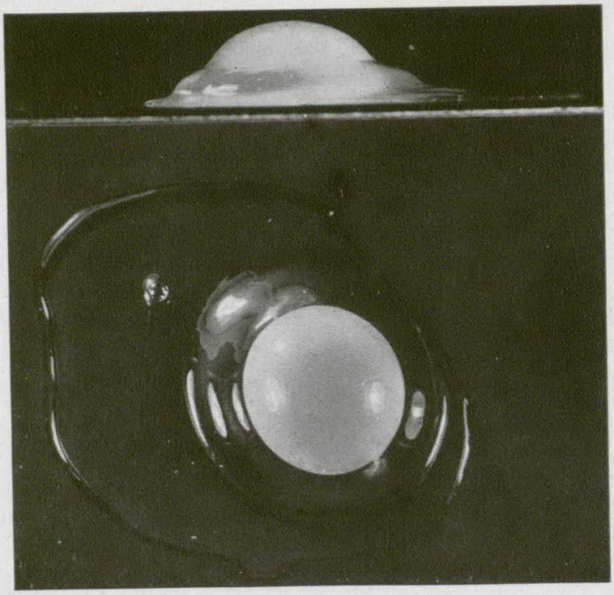


FIG. 22. A "streamliner"; in other words, a top quality egg. Note the height and curve of the yolk and the small diameter of the thick white. There is little thin white and the yolk is located directly in the centre of the thick white. This condition is only found in very high quality eggs.

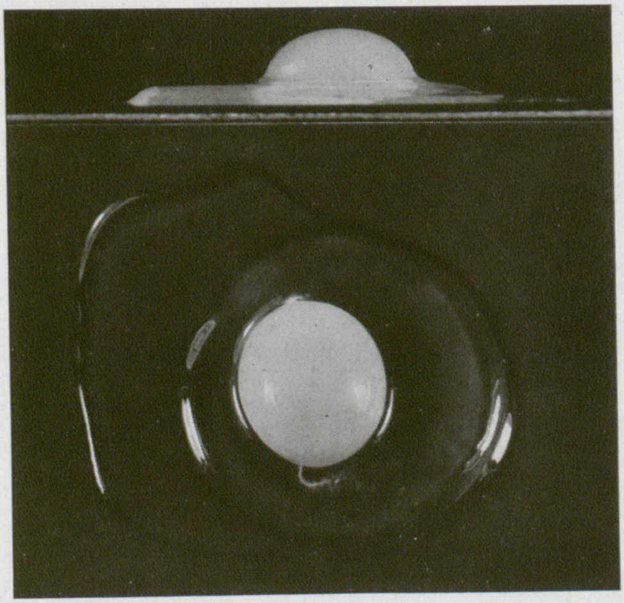


FIG. 23. A good egg. This egg is an A Grade egg and good enough to satisfy most people. Notice, however, that the yolk is lower in height and that the thick white is lower in height and greater in diameter than is the case in the streamliner, indicating some thinning out. Notice particularly that the yolk has moved somewhat to the side of the thick white and is not so well centred as in the streamliner. One or two days of storage in a moderate temperature will produce this result.

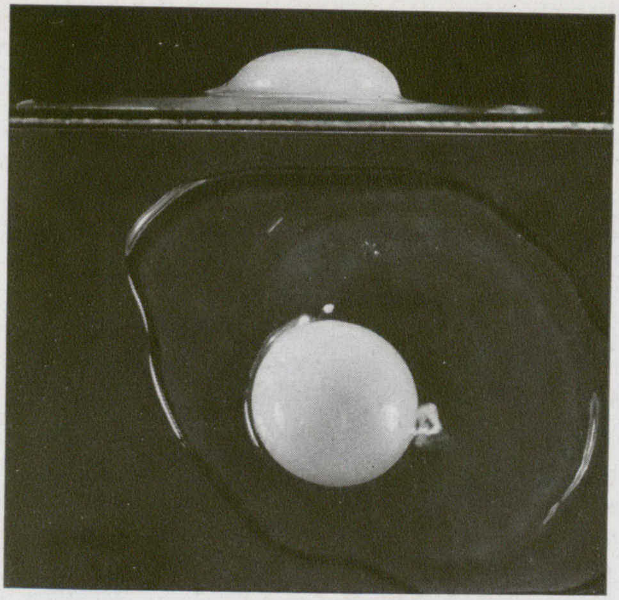


FIG. 24. A satisfactory egg but showing the effect of holding under unsatisfactory conditions or for too long a time. It would grade B Grade. The yolk has flattened and has definitely lost height. The thick white has become weak and has lost so much height that the diameter has greatly increased. The yolk is now well off to one side, but is still of good quality. Holding an egg for even one week under ordinary summer storage conditions will lower the quality of some eggs to B Grade.

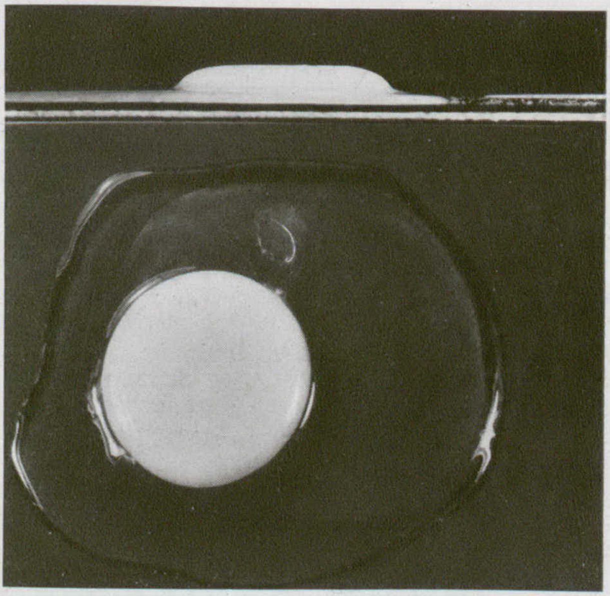


FIG. 25. An egg that was once fresh. It would still grade C Grade but is not a very good C. The yolk is badly flattened and so much enlarged that it is easily ruptured. It has moved well off to one side so that little more than half is surrounded by thick white. The thick white has almost the diameter and area of the thin white and is difficult to distinguish from the thin white. Ten days to two weeks of low humidity and rather warm temperatures, 70 to 80 degrees F., produce this result, whereas immediate cooling and proper temperatures, 50 to 65 degrees F., along with a humidity of 75 per cent, would have kept this egg in A Grade condition for an even longer period of time.

BROKEN OUT APPEARANCE OF EGGS OF CANADIAN GRADES

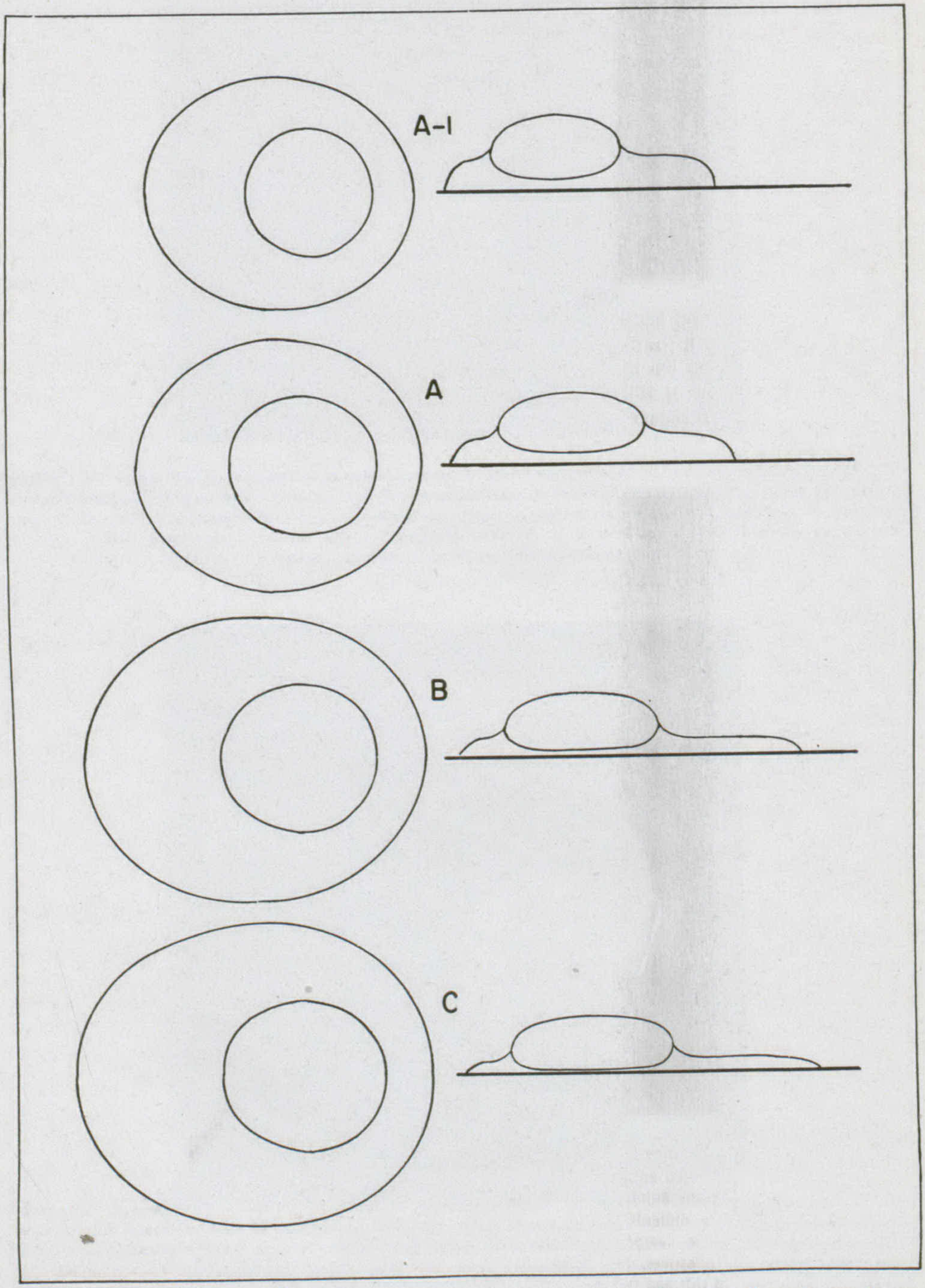


FIG. 26. Drawn from average measurements of a group of eggs of each grade as candled by a member of the Federal Inspection Service.

The difference between firm and fluid white is considered to be chiefly due to a difference in mucin fibre content, firm white having about nine times the mucin fibres present in fluid white.[3] Loss of CO_2, with its attendant increase in alkalinity, tends to cause a breakdown of the mucin fibres and as a result thinning of the firm white. This whole reaction is greatly accelerated by high temperatures, but retarded by low temperatures.

There are also normally present in eggs, certain enzymes.[3] These are organic catalysers which under certain conditions of temperature and hydrogen ion level tend to stimulate the biochemical changes which result in the thinning of egg white.

Furthermore, the absorption of water by the yolk through the yolk membrane, from the rapidly thinning white of improperly held or stored eggs, results in increased yolk volume. This is due in part at least to osmotic reaction taking place through the semi-permeable yolk membrane and results from the variation in concentration between the yolk material and the thinning white. Because of this reaction, the yolk membrane becomes stretched and weakened and the yolk flattens. It finally tends to rupture when the pH rises to or exceeds 9.5.

TABLE 11 — THE EFFECT OF AGE OF EGG ON THE PROPORTIONS OF YOLK AND WHITE

	Whole Eggs			**Edible Portion of Eggs***		
	White	**Yolk**	**Shell**	**Loss**	**White**	**Yolk**
	%	%	%	%	%	%
2-day old	57.27	30.84	11.38	0.51	65.00	35.00
Commercial	56.50	32.04	10.94	.52	63.81	36.19
Storage	52.53	35.17	11.39	.91	59.90	40.10

(U.S.D.A. Agr. Marketing Service) * Total weight less weight of white, yolk and shell.

Note the increased weight of yolks and the corresponding decreased weight of whites in the older commercial and storage eggs.

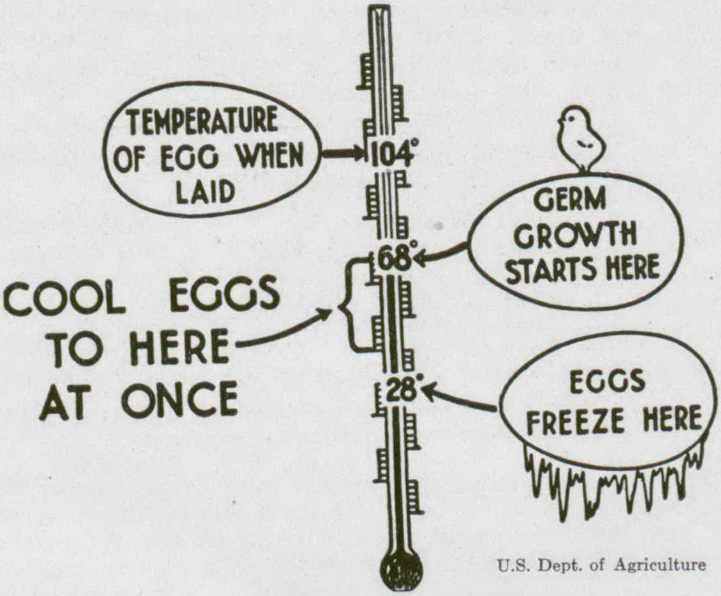
Rapid and continued cooling assists greatly in slowing down most of the reactions described. If cooled to from 50° to 65° F. directly after being laid, eggs will, if so held, keep in Grade A condition for from one to two weeks or even longer. They would retain their original quality even better at 35° to 40° F. but will sweat when later exposed for sale at ordinary room temperatures. Sweating encourages mould growth and results in musty flavours and spoilage unless necessary precautions are taken to prevent this. This may be done by removing the eggs from low into higher temperatures gradually and into air with low relative humidity. Low temperature is essential because it retards bacterial growth and also retards rapid thinning of egg white. Furthermore, as embryonic development commences in fertile eggs at 68° F., temperatures below that point serve to prevent such development.

TABLE 12 — TIME NECESSARY FOR FERTILE, FRESHLY LAID EGGS TO DETERIORATE, AT STATED TEMPERATURES, TO THE QUALITY OF U.S. STANDARD. (APPROXIMATELY GRADE B.)

Temperatures	**Time in Days**
98.6°F.	3
77.0°F.	8
60.8°F.	23
44.6°F.	65
37.6°F.	100

Sharp and Powell, Cornell University.

Much of the deterioration taking place in fresh, stored and processed eggs results from the growth of bacteria and moulds. These organisms multiply rapidly once they gain entrance because eggs are a favourable medium for their growth. While most clean eggs are practically free from bacteria, soiled eggs are heavily contaminated. Washing with tap water improves the appearance but tends to open the pores and affords greater ease of entrance. Shell membranes, albumen and yolks may quickly become infected and in spite of the germicidal effect of egg white (due to the presence of lysozyme) on many of these micro-organisms, deterioration of quality and economic loss follow. Microbial multiplication occurs only in water solution and most rapidly under fairly high temperatures. One cannot over-emphasize the need for sanitation in handling eggs nor can one over-emphasize the need for rapid cooling, as low temperatures greatly retard the growth of both bacteria and moulds. It has been repeatedly shown experimentally that eggs properly cared for rarely show contamination.


TEMPERATURE OF EGG WHEN LAID
104°
GERM GROWTH STARTS HERE
68°
COOL EGGS TO HERE AT ONCE
28°
EGGS FREEZE HERE

U.S. Dept. of Agriculture

FIG. 27. Thermometer showing correct holding temperatures.

TABLE 13 — RATE OF COOLING AS AFFECTED BY THE CONTAINERS USED

Hours	Single Egg	Wire Tray	Wire Basket	Galvanized Pail	Chilled Case	Warm Case
0	101.0° F.	102.0° F.	100.0° F.	98.5° F.	97.2° F.	92.0° F.
1	61.1	86.9	96.0	97.9	96.2	91.8
2	51.3	74.4	87.2	95.9	94.5	91.3
3	......	66.5	79.1	92.2	92.0	90.2
4	......	61.0	72.7	87.0	89.8	88.6
5	......	56.5	67.5	82.1	87.5	86.1
10	......	......	56.5	65.6	76.5	75.5

At an egg room temperature of 50° a single egg can be cooled below germ development temperature (69°) in one hour; eggs on a wire tray, 3 hours; eggs in a wire basket, 5 hours; eggs in a galvanized iron pail, 10 hours; eggs in a chilled case, 18 hours; and eggs in a warm case, 20 hours.

E. M. Funk, U. of Missouri.

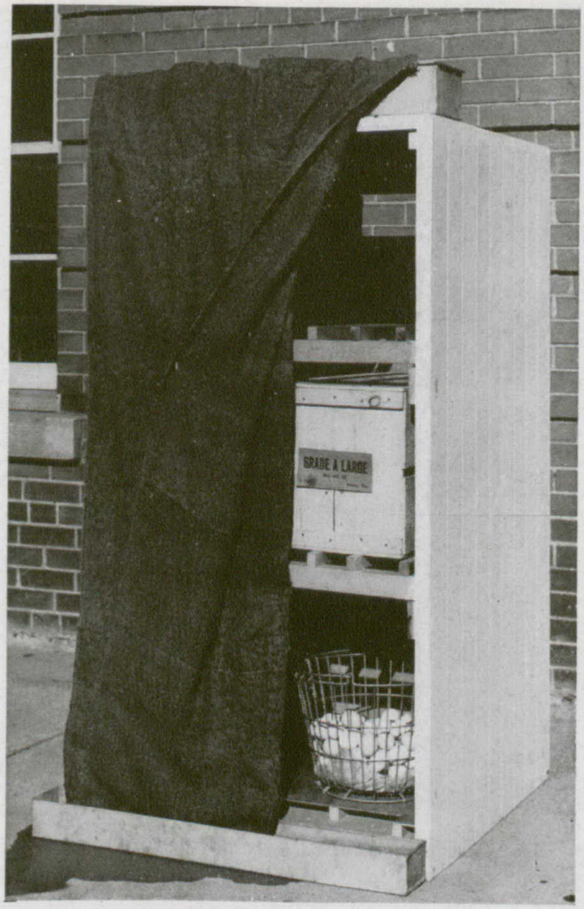


FIG. 28. Where summer storage room facilities are inadequate, this simple egg cooler will further lower the temperature and increase the humidity by evaporation of water from the jute curtain covering the front.

High humidity in the storage room retards evaporation and so slows down increase in air cell size in eggs. As the air cell size is a factor in grading, it pays the producer to hold eggs until marketed, in a room with a relative humidity of from 70 to perhaps 80%. The same is true for eggs held by the dealer and also the housewife. In cold storage warehouses eggs are frequently held at from 88 to 92% humidity, but care is necessary to create sufficient air movement to prevent mould development, otherwise likely at these high humidity levels. Eggs held at 29 to 31 degrees F. in a properly humidified storage room will keep in good condition for from 6 to 9 months.

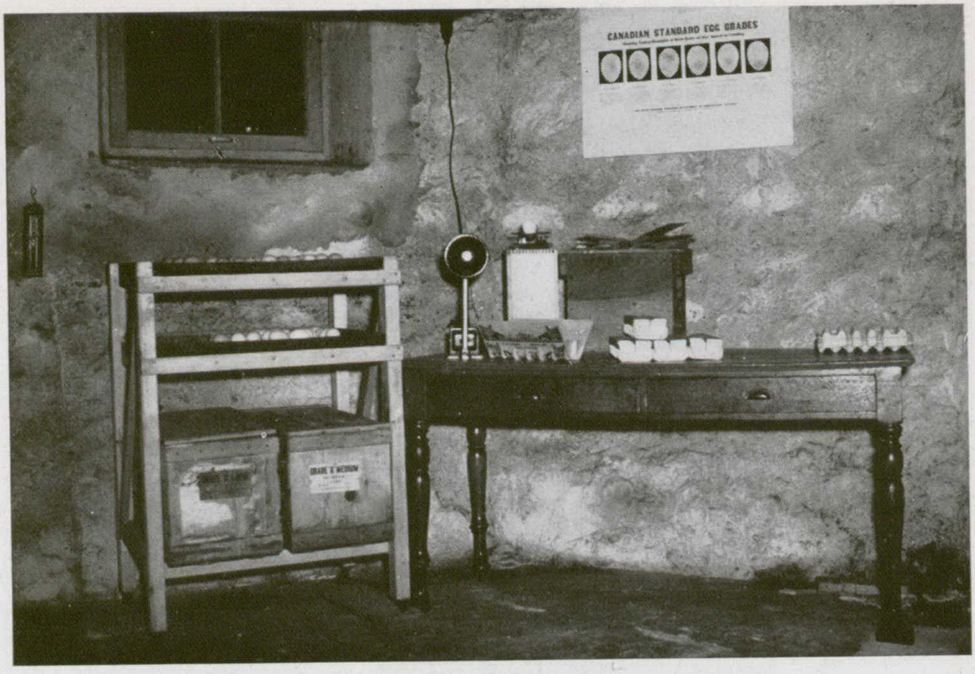


FIG. 29. Inexpensive and satisfactory equipment for properly cooling, grading and packing eggs on the farm.

The Farm Egg Cooling Room—Frequent gathering and rapid cooling of eggs on the farm are imperative for quality retention during hot weather. The northeast corner of a cool, clean basement is an excellent location for the egg room. For best results this space should be partitioned off with insulating board and fitted with wire-bottomed cooling trays, a table and necessary crates, fillers and other equipment. A good egg candle is also needed if grading is to be done on the farm. A lamp with a green filter, a good reflector and a strong, well-centred light is best. For ventilation the room should have an easily opened window, screened against flies and protected from sunlight and summer heat by shrubbery. A shade or curtain will exclude light while candling. Humidity may be increased when desirable by putting water on the cement floor, but care must be taken to prevent the development of moulds which may be done by the addition of a little formalin to the water.

A good storage room in which eggs may be held with a minimum of loss until marketed is one of the prime essentials for improving market egg quality. Holding eggs under unsuitable conditions results in lowered quality and reduced returns to the producer. On large commercial farms a specially constructed, well insulated room is a necessity. This may be kept cool by means of a small, thermostatically controlled refrigerating and humidifying unit. Attention to these points along with regular and frequent marketing in clean containers will assure the producer top grades and prices for his product.

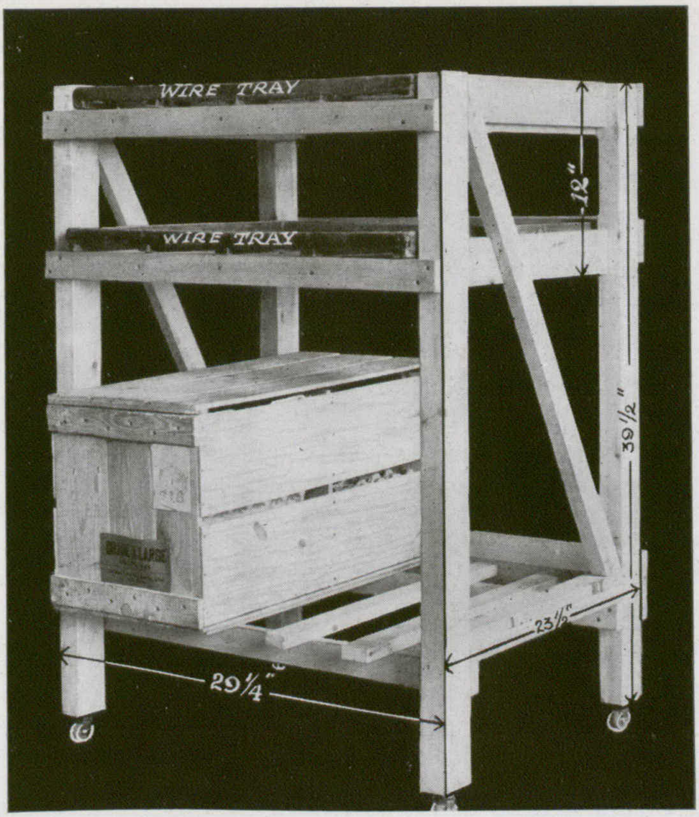


FIG. 30. A simple stand to hold one or more wire-bottomed trays and a shelf off the floor for egg cases.

OILING EGGS FOR RETENTION OF QUALITY

Oil treating eggs with a light, tasteless and colourless oil tends to close the pores and so retards CO_2 loss and reduces evaporation. This also slows down physical and chemical changes within the egg and so helps retain the original quality longer than when not treated. Certain mechanical and economic difficulties have served to limit the use of oil in the past, but these are largely being overcome. Three methods have been employed, namely, dipping, spraying and the vacuum-carbon dioxide method. The latter, developed by the Food Research Division of the U.S. Bureau of Agricultural Chemistry and Engineering, has given excellent results though the dipping and spray methods are better known and more extensively used. All these methods, because of equipment needed, are only practical at central collection points. The proper physical constants (specific gravity, viscosity and pour point) are more important than the quantity of oil applied. Recent experiments at the Michigan Agricultural Experiment Station indicate the possibility of adding an antibiotic or germ-killing agent to a suitable oil and applying such an oil to eggs on the farm immediately after being cooled, and within 24 hours after being laid.[11] In this way bacteria and mould spores on the shell are destroyed and the original egg quality largely retained, more so than at present when oil dipping, if done at all, is done after the eggs reach the wholesaler, by which time considerable quality deterioration may have already taken place.

KEEPING THAT GOOD EGG GOOD

As has already been suggested, judged by any reasonable standards, healthy, well-bred, well-fed and properly managed hens will, with relatively few exceptions, lay high-quality eggs. The few exceptional eggs can, for the most part, be readily candled out and discarded. What is important is that the quality put into the egg by the hen be retained until the egg is consumed. To do this requires maximum efficiency on the part of all engaged in the industry, commencing with the producer and ending with the housewife or chef. A chain is only as strong as its weakest link. Carelessness on the part of either the farmer, grading station operator, first receiver, transporting agency, wholesaler, or retailer, will result in lowered egg quality and decreased consumer satisfaction and demand. To most successfully bridge the gap between the nest and skillet requires the utmost in gentle, speedy handling and the maximum in control of temperature, humidity and sanitation.

The eye and appetite-teasing appeal and consequently the maximum use in Canadian and other consumer diets of this health-producing food, depends largely upon the recognition of these facts followed by suitable and definite action on the part of all concerned.

Following is stated in tabulated form, control measures of the factors recognized as affecting production and retention of egg quality:

1. Produce infertile eggs except during the breeding season. Cockbirds make good soup and pot-pie, but do not increase production nor improve summer egg quality. At summer temperatures (85° to 95° F.) a fertile egg will germinate sufficiently that the embryo will be visible to an alert candler in as little as 72 hours.

2. Keep a well-balanced laying mash available at all times even if the layers are allowed free range.

3. Feed grain such as wheat and oats or barley daily. Depriving the layers of mash and grain forces them to become scavengers. Excessive consumption of greenstuffs, insects and waste, results in highly-coloured yolks and may also produce marked and undesirable flavours. Such eggs are not attractive or palatable to the consumer.

4. Prevent dirty eggs by providing one clean, well-bedded nest for every four or five birds and by providing clean pens, clean or screened off dropping boards or pits and clean, dry yards.

5. Confine the flock until noon on wet days and fence layers out of wet and dirty barnyards.

6. Confine broody hens and if possible close the nests at night to prevent roosting therein with resultant fouled bedding.

7. Gather eggs frequently, at least three times per day. This helps prevent quality loss by frost in winter and sustained high temperatures in summer. It also prevents accumulation of eggs in the nests and subsequent breakage.

8. Handle eggs carefully and with clean, dry hands and in clean utensils. Cracked and soiled eggs result in great loss to the producer and also to the whole industry.

9. Cool eggs quickly by storing immediately after gathering in a clean, cool and moderately humid room or basement. Storage room temperature of from 50° to 65° F. with a relative humidity of from 65 to 80 per cent is practical and will usually satisfactorily conserve quality. Most rapid cooling is secured by spreading on a wire-bottomed tray as illustrated (Fig. 30). This also aids in the location of soiled, cracked and abnormal eggs. Wire baskets and moulded egg trays, though less efficient, may also be used for this purpose and afford more rapid cooling than do pails or fruit baskets. Where room temperature and humidity are borderline, a home-made cooler may pay well for time and labour, (Fig. 28) and where sufficient volume of eggs is produced, a commercial cooling and humidifying unit may be a necessity.

10. Pack in clean cases, flats and fillers to prevent soiling and mould development. Moulded packing material, such as Keyes trays or cup flats, is efficient in avoiding breakage and loss. It also facilitates rapid handling.

11. Pack eggs with large ends uppermost as this tends to keep the yolks well centred. Eggs left lying for days on their sides tend to show darker yolk shadows when candled because the yolks rise nearer the surface.

12. Handle eggs gently and carefully at all times to prevent injury to the interior structure. Rough handling may cause tremulous air cells and may even rupture weak yolk membranes.

13. Have your eggs graded at a registered grading station or grade them yourself at the farm. Badly stained, poor shelled and cracked eggs are best used at home. Eggs often deteriorate considerably, especially during hot weather, if handled through a first receiver rather than through a registered grading station, as many first receivers lack facilities for proper holding and also for rapid movement to grading stations. This often results, according to statistics from across Canada, in from 10 to upwards of 25 per cent lower grade eggs, the producer taking the loss.

14. Market eggs regularly, at least twice each week if possible, especially in summer. Eggs never improve with age.

15. Move eggs rapidly through the marketing channels either to the consumer or the cold storage room.

16. Transport to market in a covered conveyance and if possible in the cool of the day or at night. Refrigerated trucks should be used. More care is often taken in the transportation of alcoholic and other beverages than in the handling of our very necessary and highly nutritious eggs.

17. Retail in stores from a refrigerator case similarly to butter and other perishable products.

18. Store in the home until used in a cool, fairly humid place, the household refrigerator being excellent for this purpose.

TABLE 14 — COMPARISON OF GRADES AND RETURNS FROM THIRTY DOZEN EGGS FROM EACH OF SIX FARMS
WEEK OF APRIL 2, 1945

Flock No.	Large	Medium	Pullet	% A Grade	B Grade	% B Grade	C Grade	% C Grade	Cracks	% Cracks	Rejects	% Rejects	Returns	Loss per Case	Average Price Rec'd per Dozen
Perfection	30-0	0-0	0-0	100.0	0-0	0	0-0	0	0-0	0	0-0	0	9.00	0	30.0c
Flock No. 1	28-7	0-5	0-0	96.6	0-2	.55	0-0	0	0-8	2.2	0-2	.55	8.80	.20	29.3c
Flock No. 2	18-6	4-11	0-8	80.3	2-11	9.7	0-6	1.7	2-5	8.1	0-1	.28	8.34	.46	27.8c
Flock No. 3	11-2	4-10	4-8	68.8	6-6	21.7	0-3	.83	2-7	8.6	0-0	0	7.92	.88	26.4c
Flock No. 4	14-5	4-8	0-4	64.4	8-10	29.4	0-2	.55	1-7	5.3	0-0	0	8.27	.53	27.6c
Flock No. 5	0-0	0-0	0-0	0.0	22-6	75.0	6-0	19.87	1-2	3.8	0-4	1.2	6.90	1.90	23.0c
Flock No. 6	1-9	0-1	0-0	6.1	27-6	91.7	0-1	.28	0-5	1.4	0-2	.55	7.50	1.30	25.1c
Paying Price Per Dozen	30c	29c	23c		25c		18c		16c						

NOTE: Flock No. 1—Excellent.
Flock No. 2—Excessive number of cracked and soiled eggs.
Flock No. 3—Excessive number of soiled and cracked eggs.
Flock No. 4—Large number soiled.
Flock No. 5—Preponderance of soiled eggs.
Flock No. 6—Graded down largely because of of dark yolks.

A thorough understanding and the best possible control of the foregoing conditions and factors influencing eggs and egg quality are imperative for maximum success in the production and sale of market eggs. Widespread application of this knowledge will result in a product that will create and retain the confidence of consumers at home and abroad. Furthermore it will put dollars into the pockets of observant and adept producers.

As a practical example, facts gleaned from a visit on April 2nd, 1945, to a typical egg grading station located at the Guelph Creamery, Guelph, may well be cited. From the day's receipts grade slips for thirty dozen eggs from each of six representative producers were selected and studied. The results are tabulated in Table 14 and illustrated in Figure 31. Grade A Large eggs commanded 30 cents per dozen on that date, or $9.00 per case. It is illuminating to compare the high percentage of Grade A eggs received from Flock No. 1 and the subsequent high returns, with the percentage of Grade A eggs and the returns for a similar number of eggs from the other five flocks.

Unseasonable numbers of small eggs in Flock No. 3 indicate faulty breeding and management. Inadequate help is a possible contributing factor in the excessive number of soiled and cracked eggs from Flocks No. 2, 3, 4 and 5. Flock No. 6 was probably turned outdoors, deprived of laying mash and the birds forced to become scavengers. Is it not also possible that most or all of the flock owners were somewhat careless in failing to realize the perishability of their product and its dependence for quality on proper feeding and management? In any event it cost them money. It also lowered the quantity of top quality eggs obtainable for market and export.

It is a serious nutritional and economic waste to lower egg quality through a lack of knowledge of requirements and through careless handling.

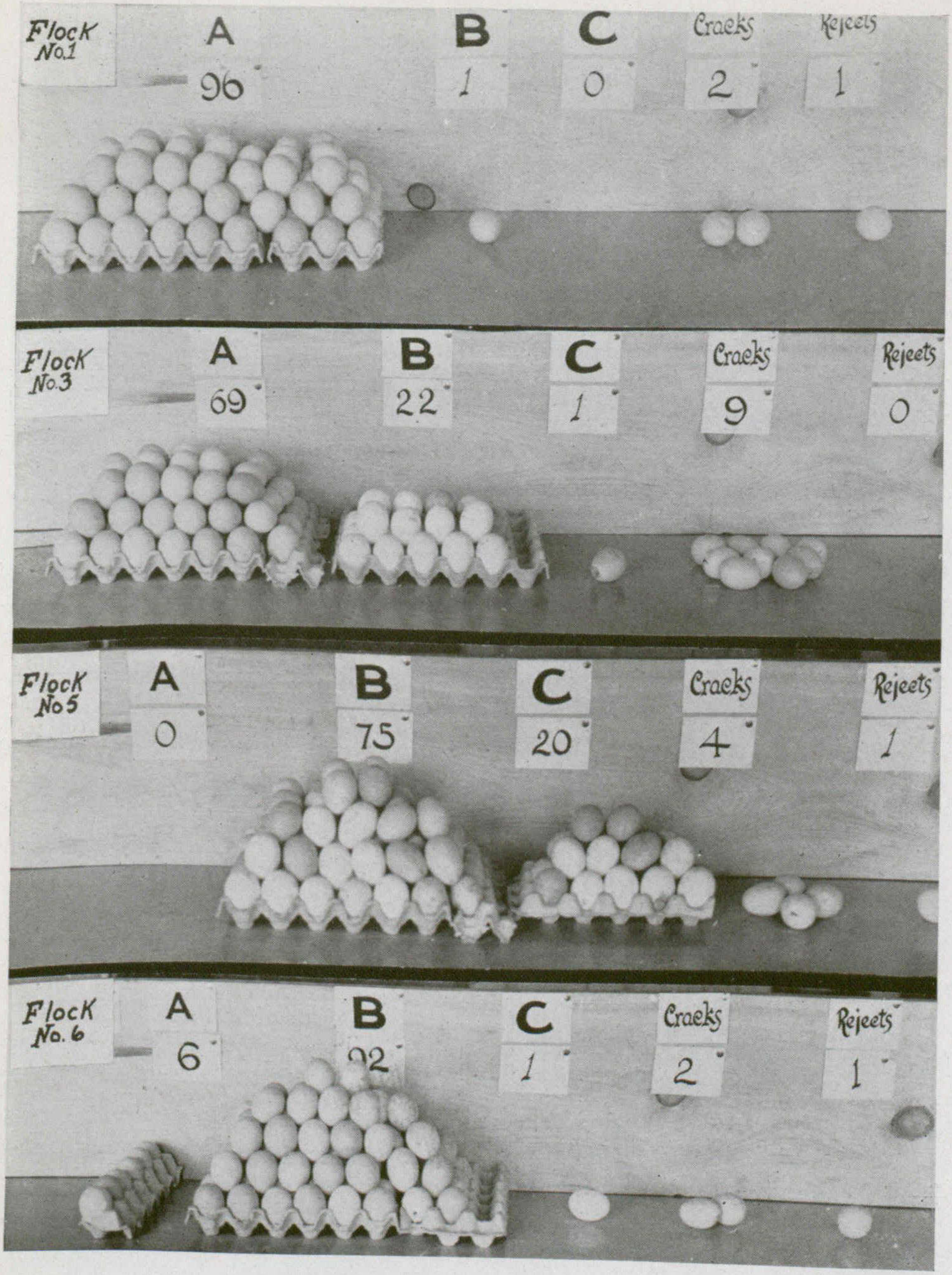


FIG. 31. Photographic representation of the number of eggs of each grade in the cases of eggs brought to the grading station on April 2nd, 1945, from each of flocks 1, 3, 5 and 6. (See table 14.)

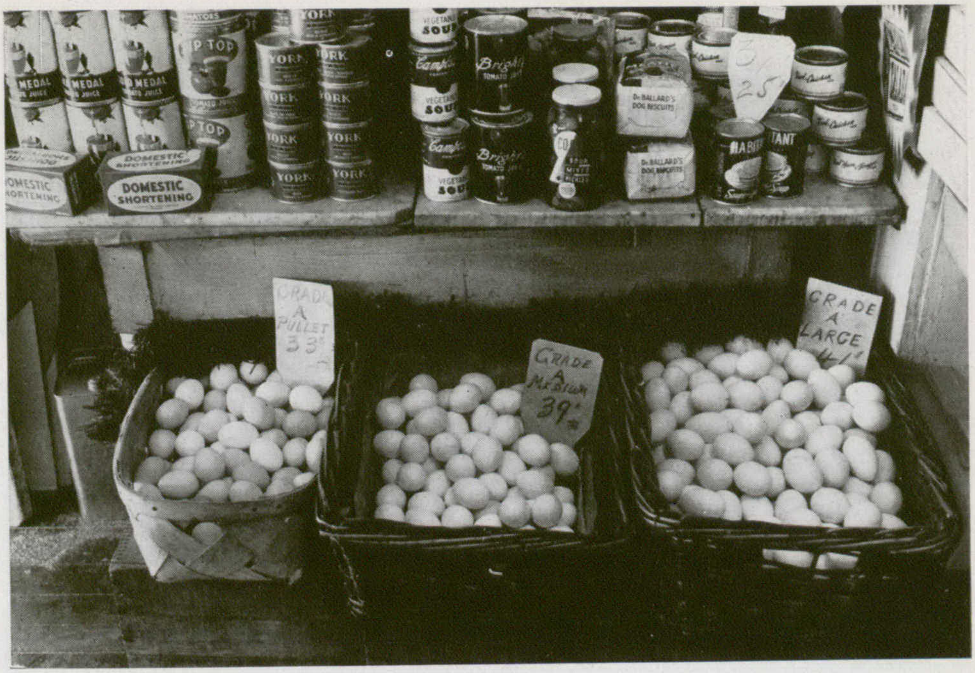


FIG. 32. Eggs exposed for sale in this way lose quality very rapidly, especially in a warm, dry store.

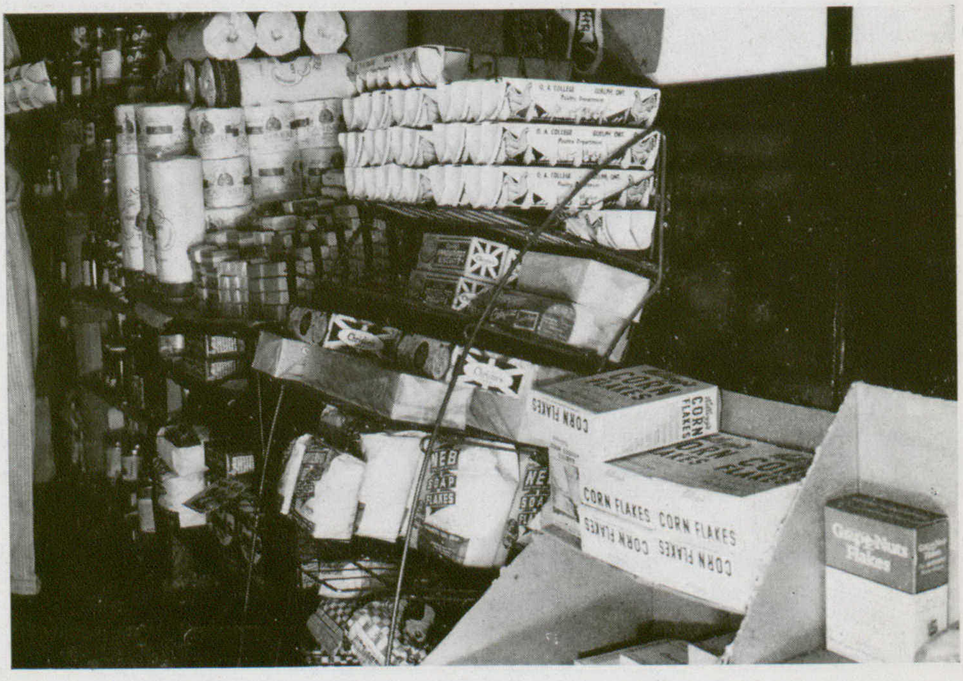


FIG. 33. Cartons facilitate handling, but do not materially protect quality when eggs so packed are exposed for sale for hours or even days in a warm, dry store.

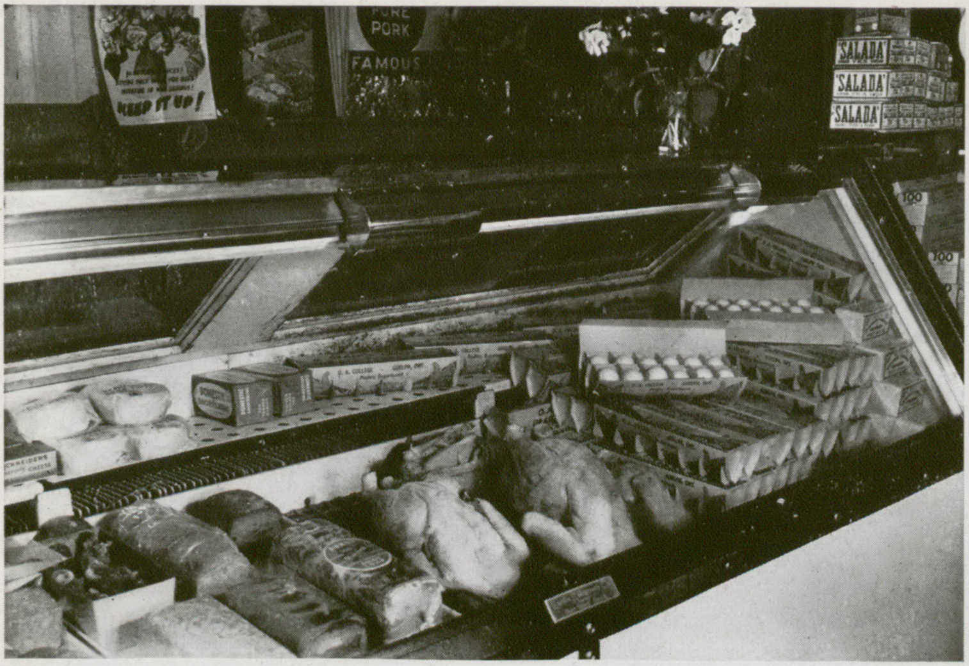


FIG. 34. Eggs should be kept in the refrigerator until sold, or exposed for sale in a refrigerator case as are most other perishable products.

FIG. 35. "The proof of the pudding is in the eating." Pleasure, satisfaction and health result from the consumption of quality eggs.

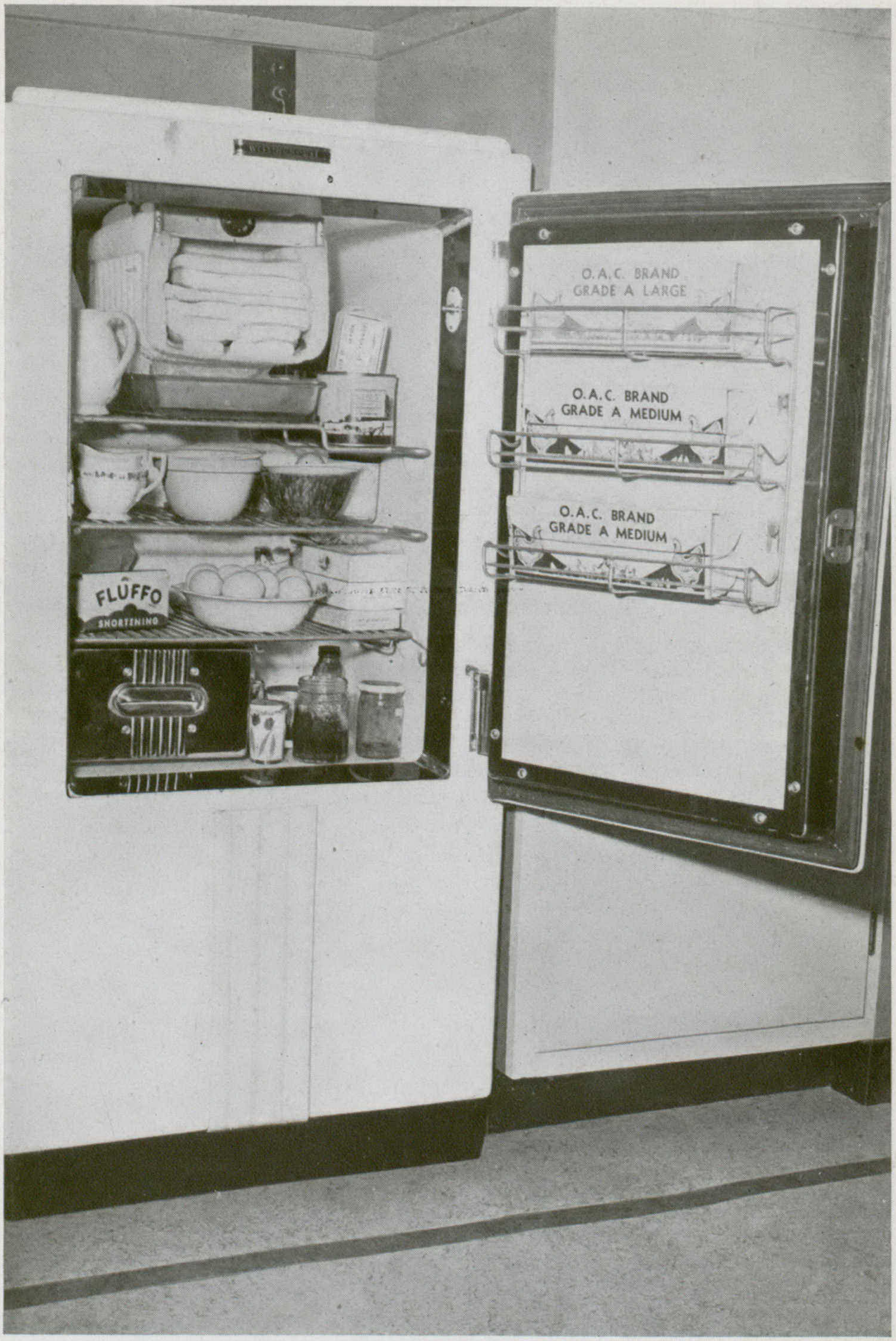


FIG. 36. After purchase eggs should be held in the household refrigerator until used.

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